

THE OHIO JOURNAL OF SCIENCE

VOL. 61

SEPTEMBER, 1961

No. 5

MORPHOLOGY AND DISTRIBUTION OF *BRANCHINELLA KUGENUMAENSIS* (ISHIKAWA), VAR. *MADURAI* RAJ

(BRANCHIOPODA: CRUSTACEA)

P. J. SANJEEVA RAJ*

Department of Zoology, University of Connecticut, Storrs, Connecticut

INTRODUCTION

Based on Daday's (1910) monograph on the Anostracan Phyllopoda, Kemp (1911) recorded and described 5 genera, with 5 species and 1 variety representing 4 families of Anostracan Phyllopoda from India. Bond (1934), studying the Indian Anostraca on the basis of large collections of the Indian Museum, described 6 genera with 7 species and 4 subspecies belonging to 4 families. However, the genus *Branchinella* Sayce was first recorded from India by myself (Raj, 1951). Specimens collected very closely resemble *Branchinella kugenumaensis* Ishikawa, but in view of the fact that the frontal appendage in the Indian forms is more spinous, the basal joint of the antenna bears more fleshy processes, the bracts and flabella are of varying shapes, and above all the wide geographic distribution from the type locality in Japan, these have been assigned to a new variety *madurai*. In the present paper a detailed account of its morphology with notes on its distribution is given.

MATERIAL AND METHODS

About 70 specimens were sent to me which were collected by the late Mr. K. J. Joseph in August and December, 1951, from the fresh water ponds in Madura, which is about 300 miles southwest by south of Madras and about 80 miles from the nearest coast line. Subsequent careful survey of the ponds in and around Madras revealed specimens of *Branchinella kugenumaensis* coexisting with *Streptocephalus dichotomus* Baird, at two places, Pallavaram and Tambaram, which are 12 and 17 miles respectively south of Madras, but only about 10 miles from the coast line.

Specimens collected were kept alive for purposes of observation in new earthenware, wide-mouthed vessels which were kept indoors. These proved to be excellent aquaria in view of their porosity, saving the trouble of changing water once a week. Pulped fresh water algal scrapings from stagnant ponds served as satisfactory food for them. Collections in July and August contained ovigerous females, which laid eggs in these aquaria. Eggs were dried in the sun for about a month, which seemed necessary for their hatching in the laboratory.

MORPHOLOGY

Males are readily distinguishable from the females by the complex frontal appendage, biarticulate cylindrical antennae, and a pair of spinous penes. Females besides lacking the frontal appendage, have an unsegmented flat antenna and an ovisac.

In the living state, the body is uniformly flesh colored in both sexes, translucent, so that the tubular alimentary canal and the gonads are visible from the exterior.

*Danforth Fellow on leave from Madras Christian College, Tambaram, South India.

Male.—The abdomen and the caudal furca are together slightly longer than the head and thorax.

Head in the male is prolonged in front of the median eye, as the frontal appendage which lies superior to the antennae. In the living state the frontal appendage is kept either bent twice underneath the head or stretched forwards, when it measures 7 to 8 mm in length. It is three-jointed (fig. 1) and branches thrice on its length. The proximal joint is a mere anterior continuation of the head, subcylindrical and slightly curved ventrally. On either side of the ventromedian line it bears a double row of about 5 pairs of digitiform, two-segmented processes. The second or middle joint is short and straight, bearing ventrally 8 pairs of these processes. At its distal end the middle joint branches into 2 rami, each bearing a single row of such processes. Each ramus branches twice. The inner branch is tapering and is spinous throughout its surface, but the outer branch divides once again for the third and last time. Both of these ultimate branches are rather spinous.

Antennules are unsegmented and filamentous (fig. 2a), each about 4 mm in length. They are located at the base of the eye stalks and at the distal extremity, each bears in addition to 3 long sensory hairs, about 4 to 6 smaller two-segmented blunt processes (fig. 2b).

Antennae (fig. 3) are about 4 mm long, biarticulate, and are located at the base of the frontal appendage. As in males of all the other Anostraca, they are modified here also, and are directed forwards. The basal segment is flattened and fleshy, broadest at its middle point where it bears the distal segment, towards the outer side. The basal segment carries 10 prominent fleshy processes towards the outer margin. The distal segment of the antenna is falciform, more chitinous and movably articulated.

Eyes (fig. 4) are dark and hemispherical and borne on movably articulated stalks. The median or the nauplius eye is at the base of the frontal appendage on a line joining the bases of the 2 antennules. It is elongated anterior-posteriorly, and shows a clear transverse constriction in the middle, giving a bilobed appearance.

Labrum (fig. 5) is a continuation of the head beneath the frontal appendage, roughly triangular and directed backwards. It has a dense setose margin and at the free end is drawn into a tonguelike process. The labral glands are prominent.

Mandibles (fig. 6a) are club-shaped on either side of the mouth, with hollow and narrow proximal ends inserted to muscles, and the free end has 2 ridges with fine denticles and larger spines at the anterior end (fig. 6b). No palps are noticeable.

Maxillulae (fig. 7) are small, unsegmented, and flat with the free margin fringed with 17 to 18 biarticulate plumose setae.

Maxillae are very rudimentary, irregularly lobed with few setae, but often inconspicuous.

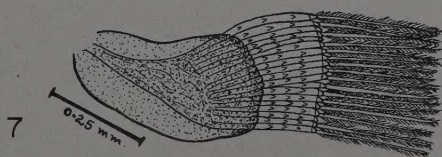
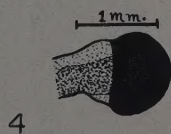
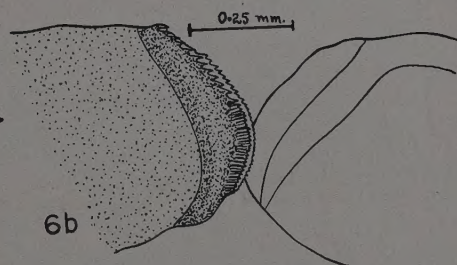
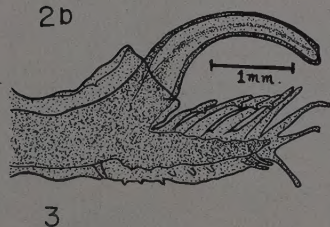
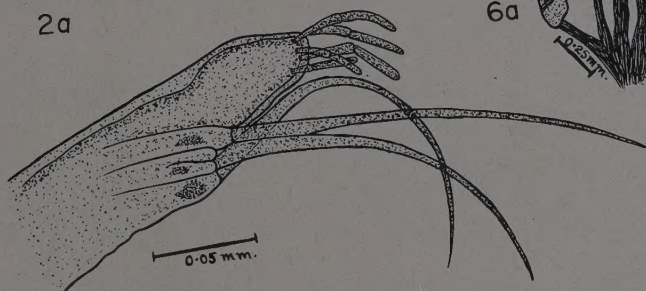
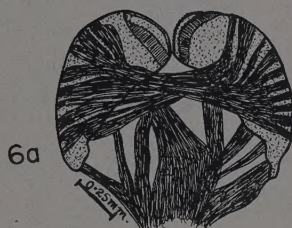
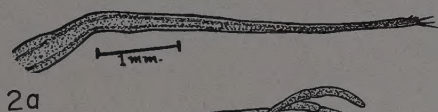
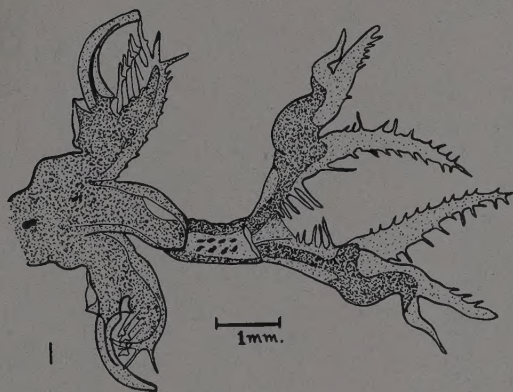
Thorax bears 11 distinct pedigerous segments, each with a pair of phyllopodia. The anterior ones are noted to be slightly smaller than the posterior ones.

Phyllopodia (fig. 8) are flat and leaflike. Of the 6 endites toward the interior, the distal most one is the largest, usually circular, but in some cases bifid by a notch. The setae along its margin are reduced to short spines. The proximal most endite bears very long plumose setae, whereas the intermediate endites are small, conical, each bearing 3 to 5 setae. Towards

EXPLANATION OF FIGURES

Branchinella kugenumaensis (Ishikawa), var. *madurai* Raj.

- FIGURE 1. Frontal appendage and antennae of male.
2a. Antennule of male.
2b. Tip of antennule.
3. Antenna of male.
4. Eye.
5. Labrum.
6a. Mandibles.
6b. Mandibular edge.
7. Maxillula.



the exterior the phyllopodium carries the exite (epite) at the proximal end whose shape is uniform in all the appendages, circular and with a crenulate margin. The bract or the gill is fleshy or succulent, and has no setae. It is semicircular or tongue-like and the shape varies very much in various appendages. The flabellum bears the longest plumose setae, especially helpful in swimming. It is smaller than the bract in the anterior as well as the posterior appendages, but in the middle ones, it attains large proportions.

Running along the ventromedian line of the thorax and bound on either sides by the basal endites of the phyllopodia, there is the median food groove, along which food particles are wafted to the mouth.

Abdomen bears 9 post-pedigerous (abdominal) segments, of which the penultimate one is the longest and the last one bearing the caudal furca is the shortest. The first 2 abdominal segments are continuous ventrally forming the genital segments bearing the genital organs.

Penis is a retractile and eversible structure. The basal portion constituting the sheath is non-eversible and extends to the middle of the third abdominal segment (fig. 9a). In the retracted condition, the penis lies folded within the abdominal cavity, but when projected, extends to the hind end of the fourth abdominal segment and may measure about 4 mm in length. This distal intromittant part is vermiform and curved, and bears proximally directed spines all over its surface (fig. 9b). The basal part of this intromittant penis bears a blunt, non-spinous apophysis.

Caudal furca (fig. 10) consists of 2 cercopods, movably articulated to the last abdominal segment. The anus lies between these 2 cercopods. Each cercopod is lanceolate and is fringed at both margins with long plumose setae.

Average dimensions of an adult male.—Total length, 23.5 mm; head and thorax, 11 mm; abdomen, 9 mm; caudal furca, 3.5 mm.

Female.—Head is rounded, smooth, and unarmed.

Antennae (fig. 11) are unsegmented, flattened, and leaf-like, twice as long as their width. Distally, the outer end is prolonged as an acutely pointed process. Each antenna is about 2 to 3 mm long and bears sparse setose margin.

Abdomen is distinctly longer than the head and trunk in the female.

Ovisac is about 5 to 6 mm long, ventrally attached to the genital segments by its front end. Posteriorly it is free from the abdomen (fig. 12a) and extends up to the middle of the sixth abdominal segment. It is globular at its proximal end (fig. 12b) and abruptly narrows towards the posterior end. At its free extremity, there is a transverse slit bound by upper and lower lips for the exit of eggs.

Eggs (fig. 13) in each ovisac at a time may be 200 to 250. They are round, cream colored, and measure about 0.3 to 0.4 mm in diameter, and are externally sculptured with hexagonal facets.

Average dimensions of an adult female.—Total length, 26.5 mm; head and thorax, 10 mm; abdomen, 13.0 mm; caudal furca, 3.5 mm.

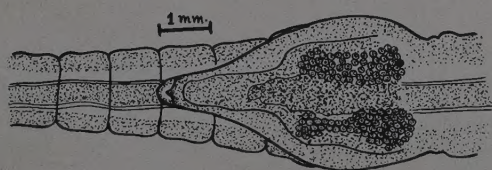
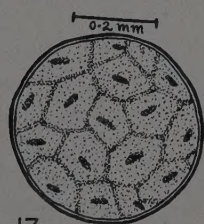
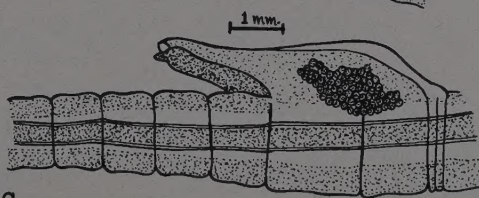
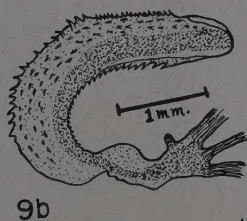
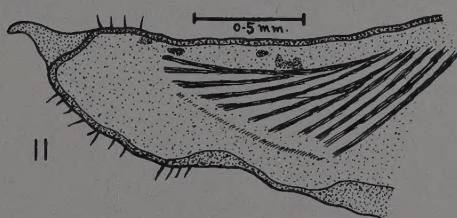
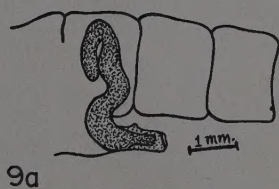
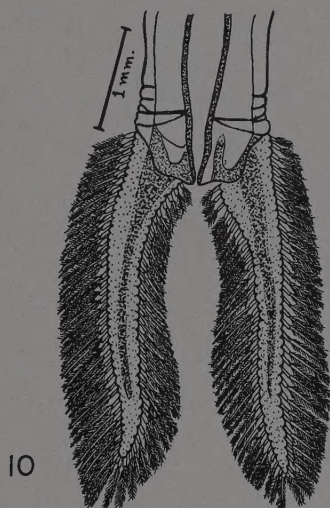
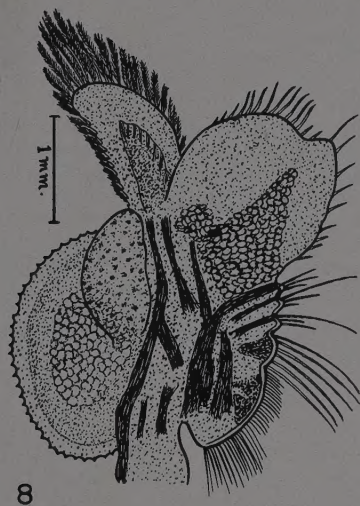
GEOGRAPHIC DISTRIBUTION

Branchinella kugenumaensis (Ishikawa) is at present known to be distributed in Kugenema, Peiping, Chefoo, Hopei, Shantung, Sagami, Tokyo, Osaka, Chosen, and Nanking.

EXPLANATION OF FIGURES

Branchinella kugenumaensis (Ishikawa), var. *madurai* Raj.

- | | | |
|--------|------|------------------------|
| FIGURE | 8. | Phyllopodium. |
| | 9a. | Penis retracted. |
| | 9b. | Penis extended. |
| | 10. | Caudal furca. |
| | 11. | Antenna of female. |
| | 12a. | Ovisac (lateral view). |
| | 12b. | Ovisac (ventral view). |
| | 13. | Egg. |



12b

In South India, it is so far known from Madura in the Madura district, and from Pallavaram and Tambaram in the Chingleput district of the Madras State. It is difficult to account for this discontinuous distribution in Japan and China at one extremity and in South India at the other. However, it is well known since ancient times that the fresh water entomostracans, especially the Phyllopods, have means of wide distribution to the remote corners of the globe through the agency of their resistant eggs, usually transported attached with mud to the feet of wading migrant birds, or through other means.

SUMMARY

The genus *Branchinella* Sayce is reported from 2 localities in South India and the morphology of a new variety of *Branchinella kugenumaensis* (Ishikawa) is described. The disjunct distribution of this species and the geographic isolation of the variety are indicated.

ACKNOWLEDGEMENTS

I am grateful to Dr. Ralph W. Dexter, Kent State University, for kindly going through the manuscript of this paper.

LITERATURE CITED

- Bond, R. M. 1934. Report on Phyllopod Crustacea (Anostraca, Notostraca and Conchostraca) including a revision of the Anostraca of the Indian Empire. Mem. Conn. Acad. Sci. 10: 29-62.
- Daday, E. V. 1910. Monographie systematique des Phyllopoques Anostraces. Ann. des Sci. Nat. Zool. et Biol. Animale. 11: 91-489.
- Kemp, S. 1911. Anostraca of the Indian Museum. Rec. Ind. Mus. 6: 222-223.
- Raj, P. J. S. 1951. The first record of the genus *Branchinella* Sayce, in India and a new variety of *Branchinella kugenumaensis* (Ishikawa). Curr. Sci. 20: 334.

A SURVEY OF SOUTHERN ILLINOIS AQUATIC VASCULAR PLANTS

ROBERT H. MOHLENBROCK, GARY E. DILLARD, AND THOMAS S. ABNEY

Southern Illinois University, Carbondale

This study is a floristics survey of the aquatic habitats and aquatic vascular plants in southern Illinois (See fig. 1). After a discussion of aquatic situations there is appended a check-list of aquatic vascular plants from southern Illinois.

The southern tip of Illinois forms a wedge-shaped area bounded by the Mississippi River to the west and the Ohio River to the east. The mainland is traversed by a number of rivers and streams, the most notable of which are the Cache and Big Muddy Rivers. Numerous man-made and natural lakes and ponds occur, the largest being concentrated in the Williamson County area. Limestone sinks are common in a few areas. Swamps and swampy woods are frequent in the extreme southern tip of Illinois, and these harbor plants which are rare or absent in other parts of the state. In addition, a few other less important aquatic habitats may be found.

The study, begun by the senior author several years ago, was intensified during the summer of 1959 with the aid of a National Science Foundation Undergraduate Research Participation grant* in which the two junior authors participated.

*Grant G-8385, National Science Foundation.

UBIQUITOUS SPECIES

A number of southern Illinois aquatics may be considered ubiquitous—i.e., they occur frequently in any type of aquatic situation. Woody plants with wide distribution are black willow (*Salix nigra*), cottonwood (*Populus deltoides*), hackberry (*Celtis occidentalis*), and buttonbush (*Cephalanthus occidentalis*). Eight grasses are ubiquitous—*Eragrostis spectabilis*, fowl manna grass (*Glyceria striata*), panic grasses (*Panicum agrostoides*, *P. anceps*, *P. polyanthes*, and *P. tennesseense*), and two species of bead grass (*Paspalum circulare* and *P. pubescens*). Ubiquitous sedges include *Carex vulpinoidea*, *Cyperus esculentus*, *Eleocharis obtusa* var. *obtus*, *E. tenuis* var. *verrucosa*, and *Scirpus atrovirens*. Although numerous herbaceous species are aquatic, most seem to have preference for one type of aquatic situation over another. However, a few are tolerant to all aquatic conditions. These are yellow cress (*Rorippa islandica*), ditch stonecrop (*Penthorum sedoides*), *Ammannia coccinea*, frog-fruit (*Phyla lanceolata*), hedge hyssop (*Gratiola neglecta*), *Lindernia dubia*, *L. anagallidea*, beggar's tick (*Bidens aristosa*), and *Eclipta alba*.

RIVERS AND STREAMS

General.—While a great number of streams with varied conditions occur in southern Illinois, several species of vascular plants are common to all. (Under each major division the ubiquitous species will not be repeated.) Sycamore (*Platanus occidentalis*), river birch (*Betula nigra*), sandbar willow (*Salix interior*), swamp chestnut and pin oaks (*Quercus michauxii* and *Q. palustris*), and silver maple (*Acer saccharinum*) are woody species found along all waterways. Among the herbaceous species which occur along nearly all rivers and streams are woodreed (*Cinna arundinacea*), pony grass (*Eragrostis hypnoides*), sedges (*Cyperus acuminatus*, *C. aristatus*, *C. erythrorhizos*, *C. ferruginescens*, and *C. strigosus*), tall hempweed (*Acnida altissima*), *Rorippa sessiliflora*, *Gerardia tenuifolia*, *Leucospora multifida*, and *Aster praealtus*. In addition, two high-climbing grapes abound along rivers and streams. These are *Vitis aestivalis* and *V. cinerea*.

The large rivers.—*The Mississippi River.*—The Mississippi River, which marks the western boundary of Illinois, has been investigated intensively at six stations interspersed from Cora (on the Randolph-Jackson County line) to Dogtooth Island (at the extreme southern tip of Illinois). (See figure). The Cora station (I) is wooded to within a few meters of the river. Plentiful here are swamp privet (*Forestiera acuminata*) and *Scutellaria lateriflora*. The latter not only occurs along the sandy shore-line but becomes a rank weed in the adjacent woodland. This station also has the only good stand of *Salix rigida* in southern Illinois. Station II, near Neunert, is adjacent to farmland and is somewhat disturbed. This is evidenced by the encroachment of a number of adventives along the shoreline (not included in the check-list due to their clearly adventive and temporary condition). In pure sand along the shoreline occur four rare southern Illinois plants—*Hemicarpha micrantha*, *Potentilla paradoxa*, *Rumex fueginus*, and *Jussiaea leptocarpa*. The first three of these also occur at Station III, while the last has been found a few times along the Mississippi River. Stations III and IV, both near Grand Tower, are in pure sand, but the former is in a treeless area commonly washed by river water while the latter is adjacent to a sandbar willow consocias which is infrequently inundated. Some vegetational differences occur. Station III has a greater variety of plants, including *Acalypha rhomboidea* and the only southern Illinois records of *Chamaesyce geyeri* and *Cyperus diandrus*. Conspicuous at Station IV is the winged pigweed (*Cycloloma atriplicifolium*) which often forms dense colonies. At both stations *Leptochloa attenuata*, *L. fascicularis*, and *Eragrostis frankii* are common. Station V, adjacent to a thick woodland a few hundred meters south of the bridge to Cape Girardeau, Missouri, presents no unusual vegetational patterns, although *Bidens aristosa* is very abundant.

Station VI, on Dogtooth Island, is rather sparse with vegetation because of

frequent inundations. Few trees occur at this station, and herbaceous plants are frequently dwarfed. Several species of *Cyperus*, *Gratiola lutea*, and *Jussiaea lepicarpa* are most common. In addition, the very rare *Eragrostis reptans* is found.

The Ohio River.—The Ohio River borders the southeastern corner of southern Illinois from near New Haven (Gallatin County) to Cairo. We have investigated two stations. Station VII is at Lock and Dam 53 near Olmstead. Here a rather narrow shoreline gives way to a deep floodplain woods. On the shore, besides the ubiquitous species, are *Mimulus ringens*, *Eragrostis frankii*, *Rotula ramosior*, *Gratiola lutea*, and others. The floodplain woods, dominated by cottonwood, black willows, and peach-leaved willow (*Salix amygdaloides*), is nearly overrun by the high climbing bur-cucumber (*Sicyos angulatus*). In the understory, species of *Eupatorium* and camphor weed (*Pluchea camphorata*) occur. It is here that *Melanthera hastata*, not known within several hundred miles, occurs in two rather vigorous colonies. Station VIII, at Cave-in-Rock State Park, has a sandy shoreline which ranges from 5–50 meters wide. It ends abruptly at a massive limestone bluff. That these bluffs have influenced the type of vegetation along the shore

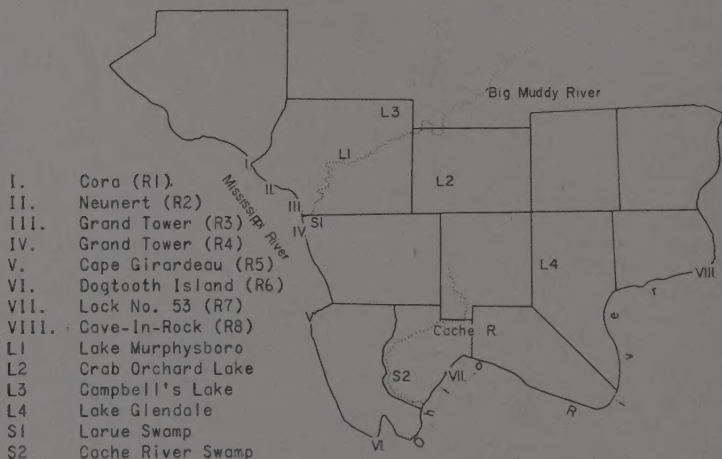


FIGURE 1. Map of the study area showing collecting stations.

is not readily observed. Only the occurrence of many plants of *Artemisia biennis* is strikingly different from any other aquatic station. Other workers have found rare species along the Ohio River. Buser has collected *Sesbania exaltata* at Mound City in Pulaski County. Palmer and Forbes have found *Tragia cordata* at Golconda in Pope County.

Of the larger rivers within the confines of southern Illinois, two will be mentioned briefly. The Big Muddy River has its source near Cravat (Jefferson County) and, after winding its way for approximately 110 miles, empties into the Mississippi River 4 miles south of Grand Tower (Jackson County). As the river nears its outlet, an interesting tree flora made up of overcup oak (*Quercus lyrata*), bur oak (*Q. macrocarpa*), swamp white oak (*Q. bicolor*), river-nut hickory (*Carya laciniosa*), and pecan (*C. illinoensis*) lines its banks. The Cache River, thought to be an old channel of the Ohio River, extends for approximately 55 miles from

near Saratoga (Union County) to Urbandale (Alexander County) near which it empties into the Ohio. The topography surrounding the Cache River is conducive to the formation of swamps and swampy woodlands (those of the Cache River will be discussed under the division on swamps). It is a common sight, however, to see bald cypress (*Taxodium distichum*), swamp cottonwood (*Populus heterophylla*), water elm (*Planera aquatica*), and others along the banks of this river. Other rivers, including the Little Muddy and the Saline, have not produced any unusual vegetational patterns.

Small streams and creeks.—Because many small streams and creeks are found deep in the valley of mesophytic woods, there frequently is an encroachment of woodland herbs along the streams. These scarcely can be considered aquatic plants and will not be discussed in this paper. The small streams usually have a typical basic flora. This is composed of the small flax (*Linum striatum*), small-flowered St. John's-wort (*Hypericum mutilum*), *Juncus tenuis*, *Spermacoce glabra*, and brookweed (*Samolus parviflorus*). Several species have selected particular streams along which to grow. Alder (*Alnus serrulata*) is common along clear Bay Creek in southeastern Illinois, but is virtually absent from the southwest (one plant has been found in Jackson County). Cow-parsnip (*Heracleum lanatum*) occurs along the same Bay Creek and also along an unnamed stream near Oraville in Jackson County. *Carex emoryi* grows in a swiftly flowing stream in Buffalo Hollow (Johnson County). *Carex substricta* has a single occurrence along Piney Creek in Randolph County; *Carex torta* is found abundantly in the middle of rapidly moving streams in a few localities. In the midst of a streamlet in Lake Murphysboro State Park is the heart-leaved plantain (*Plantago cordata*). Of more common occurrence along streams are silky willow (*Salix sericea*) and water willow (*Dianthera americana*).

LAKES AND PONDS

With the current emphasis upon southern Illinois as an outdoor recreation area, numerous artificial lakes have been developed. The largest of these are in the western part of Williamson County. In descending order of water surface acreage, these bodies of water are Crab Orchard Lake, Little Grassy Lake, and Devils Kitchen Lake. For studies of the first and third of these lakes see Hankla (1950) and Abney et al. (in press), respectively. Other lakes of considerable size in southern Illinois are Lake Murphysboro, Lake Glendale, and Pounds Hollow. All of these have a similar basic flora. In the water are coontail (*Ceratophyllum demersum*), pondweeds (*Potamogeton* spp.), naiads (*Najas* spp.), water lotus (*Nelumbo lutea*), arrowhead (*Sagittaria latifolia*), yellow water primrose (*Jussiaea diffusa*), and water lily (*Nuphar advena*). Along the shores are numerous sedges (*Carex* spp.), cat-tail (*Typha latifolia*), and rushes (*Juncus* spp.). Wolf Lake, in Union County, is bordered by pickerel-weed (*Pontederia cordata*) and arrow-arum (*Peltandra virginica*). (For a detailed account of Wolf Lake, see Mohlenbrock [1959]). Lake Glendale in Pope County is the home for *Cyperus rivularis* and *Scirpus purshianus*. The following are other uncommon species from limited localities: *Najas gracillima* from a temporary pond near Gorham in Jackson County (only Illinois station); *Echinodorus rostratus* and *Myriophyllum heterophyllum* from the pond in Murphysboro City Park; *Elodea densa* from Madison Pond near Blairsville in Williamson County (only Illinois station); *Elodea occidentalis* from a factory pond in Murphysboro; *Scirpus fluviatilis* and *Myriophyllum pinnatum* from the Randolph County Country Club Lake at Sparta; *Salix caroliniana* from a lake near DuQuoin; and *Hibiscus moscheutos* from Crab Orchard Lake. Campbell's Lake, near Elkhartville (Jackson County), should be considered in more detail because of the unusual aquatic flora which it harbors. The lake is surrounded by extensive low, swampy woodlands. The waters of the lake are shallow and present a suitable place of growth for many species. Besides the

usual species of ponds and lakes found there, several rare Illinois plants also occur. These are mosquito fern (*Azolla mexicana*), pondweed (*Potamogeton friesii*), *Wolffia columbiana*, and *W. punctata*.

A special class of ponds which are the result of strip coal mining are numerous in Perry, Jackson, and Williamson Counties. These strip mine ponds have been the subject of investigation by Bell (1956) and Brewer and Triner (1956). Because of extensive planting in these areas, numerous adventive aquatics occur. It is frequently difficult to ascertain the exact status of some of these species.

Sink-hole or upland ponds occur in southern Illinois in areas underlain by exceptionally porous limestone. Most of them are found in Hardin, Monroe and Randolph Counties. These have been investigated by Bollwinkel (1958) who found nothing but the usual aquatic species common to ponds and lakes. That many of these upland ponds were greatly disturbed through pasturing is evident by the number of adventive species which has been recorded. The Illinois "sinks" are in direct contrast to the mostly undisturbed upland ponds in southern Missouri. Steyermark has found the Missouri "sinks" to harbor many relics of the Coastal Plain flora.

A number of temporary ponds exists in southern Illinois. These are filled with water only for a portion of each year, becoming dry usually by late summer. They vary in size, but most are only a few square meters. Characteristic species are *Ludwigia palustris*, mermaidweed (*Proserpinaca palustris*), *Ammannia coccinea*, *Rotala ramosior*, camphor weed (*Pluchea camphorata*), *Lindernia dubia*, *Leucospora multifida*, and species of smartweed (*Polygonum* spp.) and beggar's-tick (*Bidens* spp.).

SWAMPS AND SWAMPY WOODLANDS

Through poor drainage in lowlands, a number of deep swamps has developed in extreme southern Illinois. As these become more shallow away from their center, the swamps give way to swampy woodlands which are inundated only briefly or not at all during the year. Two areas possess extensive swamp vegetation. One of these, in the northwestern corner of Union County, has been studied by Mohlenbrock (1959). The other area is very extensive and occurs along the entire length of the Cache River. The vegetation in both swampy areas is related distinctly to the vegetation of the Coastal Plain. Woody species include bald cypress, water tupelo (*Nyssa aquatica*), water locust (*Gleditsia aquatica*), water hickory (*Carya aquatica*), pumpkin ash (*Fraxinus profunda*), willow oak (*Quercus phellos*), swamp cottonwood, and water elm. Among the shrubs are Virginia willow (*Itea virginica*), storax (*Styrax americana*), *Euonymus americanus*, and southern buckthorn (*Bumelia lycioides*).

Since the number of herbaceous species which grow in southern Illinois swamps is so numerous, they will not be enumerated here as they do appear in the checklist. There is no distinction made in the checklist between plants of swamps and those of swampy woodlands.

Checklist of Southern Illinois Aquatic Vascular Plants

Specimens of all the following from various southern Illinois localities are on deposit in the herbarium of Southern Illinois University. A total of 352 species is enumerated. The key to the localities in the checklist is as follows:

R1—Mississippi River at Cora (I).

R2—Mississippi River at Neunert (II).

R3—Mississippi River north of Grand Tower (III)

R4—Mississippi River south of Grand Tower (IV).

R5—Mississippi River at Cape Girardeau bridge (V).

R6—Mississippi River at Dogtooth Island (VI).

R7—Ohio River at Lock and Dam Number 53 (VII).

R8—Ohio River at Cave-in-Rock
(VIII).

L1—Lake Murphysboro

L2—Crab Orchard Lake

L3—Campbell's Lake

L4—Lake Glendale

S1—LaRue Swampy Area

S2—Cache River Swampy Area

ISOETACEAE SCHAFFNER

Isoetes melanopoda Gay and Dur. Known only from a roadside ditch along Route 3, 9 miles southwest of Murphysboro. The pale-based f. *pallida* Fern. also occurs here.

EQUISETACEAE MICHX.

Equisetum arvense L. R4, R5.

Equisetum hyemale L. At nearly all stations.

Equisetum laevigatum A. Br. S2.

MARSILEACEAE R. BR.

Marsilea quadrifolia L. Campus pond, Southern Illinois University, Carbondale. Now extinct.

SALVINIACEAE REICHENB.

Azolla mexicana Presl. L3; S2.

TAXODIACEAE SCHIMPER

Taxodium distichum (L.) Rich. S1, S2.

TYPHACEAE J. ST. HIL.

Typha angustifolia L. L2; also Little Grassy Lake in Williamson County.

Typha latifolia L. In or around most lakes and swamps; rare or absent at river stations.

SPARGANIACEAE J. G. AGARDH

Sparganium angrocladum (Engelm.) Morong. S2.

Sparganium chlorocarpum Rydb. S2.

Sparganium eurycarpum Engelm. S2.

NAIADACEAE LINDLEY

Najas flexilis (Willd.) Rostk. and Schmidt. L1.

Najas gracillima (A. Br.) Magn. Found once in Illinois (1958) in a temporary pond in Jackson County.

Najas guadalupensis (Spreng.) Magn. L2.

POTAMOGETONACEAE ENGLER

Potamogeton americanus Cham. and Schlecht. L1, L2.

Potamogeton diversifolius Raf. L1, L2, L4; S2.

Potamogeton foliosus Raf. L1, L2.

Potamogeton friesii Rupr. L3.

Potamogeton pectinatus L. L1.

ALISMACEAE DC. IN LAM. AND DC.

Alisma subcordatum Raf. Most aquatic situations except along rivers.

Echinodorus cordifolius (L.) Griseb. S2; also rarely in other southern Illinois localities.

Echinodorus rostratus (Nutt.) Engelm. Known only from the "Lagoon," Riverside Park, Murphysboro.

Sagittaria brevirostra Mack. and Bush. L2; also in wet roadside ditches.

Sagittaria calycina Engelm. L1, L4.

Sagittaria graminea Michx. Wet roadside ditches along Route 3, Alexander and Jackson Counties.

Sagittaria latifolia Willd. In or around most lakes and swamps.

Sagittaria rigida Pursh. Wet roadside ditches in Alexander and Pulaski Counties.

HYDROCHARITACEAE FL.

Elodea canadensis Michx. S2.

Elodea densa (Planch.) Caspary. In Madison Pond near Blairsville, Williamson County.

Elodea occidentalis (Pursh) St. John. Factory pond, Murphysboro. Now almost certainly extinct.

Limnobium spongia (Bosc) Steud. S2.

GRAMINEAE JUSS.

Alopecurus aequalis Sobol. S2.

Arundinaria gigantea (Walt.) Muhl. Along rivers and near swamps.

Cinna arundinacea L. Along most rivers and streams.

Echinochloa crusgalli (L.) Beauv. Most moist situations.

Echinochloa walteri (Pursh) Heller. S2.

Eragrostis frankii C. A. Mey. Found at all of the river stations.

Eragrostis hypnoides (Lam.) BSP. Found at all of the river stations and most of the lake stations.

Eragrostis reptans (Michx.) Nees. R7.

Eragrostis spectabilis (Pursh) Steud. Along most of the river stations.

Glyceria arkansana Fern. S2.

Glyceria pallida (Torr.) Trin. S2. Specimen verified by Jason Swallen of the U. S. National Herbarium.

Glyceria septentrionalis Hitchc. Swampy woods northeast of Gorham, Jackson County.

Glyceria striata (Lam.) Hitchc. At all of the stations; includes var. *stricta* (Scribn.) Fern.

Leersia lenticularis Michx. R6, R7; L3, L4; S1, S2.

Leersia oryzoides (L.) Sw. L1, L2; S1, S2.

Leersia virginica Willd. L1; S1, S2.

Leptochloa attenuata (Nutt.) Steud. R3, R4, R6.

Leptochloa fascicularis (Lam.) A. Gray. R4.

Leptochloa filiformis (Lam.) Beauv. R3, R4, R6, R7.

Muhlenbergia racemosa (Michx.) BSP. R3, R5, R7; S2.

Panicum agrostoides Spreng. At nearly all of the stations.

Panicum anceps Michx. At nearly all of the stations.

Panicum microcarpon Muhl. ex Ell. L1, L2, L3, L4; S1, S2.

Panicum polyanthes Schult. At most of the stations.

Panicum tennesseense Ashe. At all of the stations.

Paspalum circulare Nash. At all of the stations.

Paspalum dissectum L. Known from Perry and Pulaski Counties. Now possibly extinct.

Paspalum fluitans (Ell.) Kunth. L4; S1, S2.

Paspalum geminum Nash. S1, S2.

Paspalum glabratum (Engelm.) Mohr. Known only from low ground in Perry County.

Paspalum pubescens Muhl. ex Willd. At nearly all of the stations.

Phalaris arundinacea L. Low ground near Route 3, eight miles southwest of Murphysboro.

Tripsacum dactyloides L. S2.

Zizania aquatica L. Known only from Union County.

CYPERACEAE J. ST. HIL.

Carex comosa Boott. S2.

Carex crinita Lam. S2.

Carex cruscorvi Shuttlw. ex Kuntze. L3; S2.

Carex decomposita Muhl. S1, S2.

Carex emoryi Dewey. Known only from a stream flowing through Buffalo Hollow in Johnson County.

Carex frankii Kunth. In or near most of the swamps and lakes.

Carex granularis Muhl. ex Willd. L1, L3, L4; S1, S2.

Carex grayii Carey. In or near most of the swamps and lakes.

Carex hyalinolepis Steud. Mostly in wet roadside ditches.

Carex lacustris Willd. Known only from a roadside ditch in Jackson County.

Carex lanuginosa Michx. L3; S1.

Carex louisianica L. H. Bailey. S1.

Carex lupuliformis Sartw. ex Dewey. S1, S2.

Carex lupulina Muhl. ex Willd. In or near most of the swamps and lakes.

Carex lurida Wahl. In or near most of the swamps and lakes.

Carex muskingumensis Schw. L3.

Carex oxylepis Torr. and Hook. Known only from a swampy woods near Dongola, Union County.

Carex projecta Mack. Roadside ditch along Route 3, 8 miles southwest of Murphysboro.

Carex retrorsa Schw. S2.

Carex shortiana Dewey. L1, L3; S1, S2.

Carex squarrosa L. In or near most of the swamps and lakes.

Carex stipula Muhl. ex Willd. L3; S1.

Carex subimpressa Clokey. Wet roadside ditch two miles south of Elkville, Jackson County.

Carex substricta (Kukenth.) Mack. in Rydb. Known only along Piney Creek, Randolph County.

Carex toria Boott. In rapid flowing streams in Jackson, Johnson, Pope, and Randolph Counties.

Carex typhina Michx. R5, R6; S1.

Carex vulpinoidea Michx. In all moist situations.

Cyperus acuminatus Torr. and Hook. At all of the river stations.

Cyperus aristatus Rottb. At all of the river stations.

Cyperus densicaespitosus Mattf. and Kukenth. in Kukenth. L1, L4.

Cyperus diandrus Torr. R4.

Cyperus engelmanni Steud. S2.

Cyperus erythrorhizos Muhl. At all of the river stations.

Cyperus esculentus L. At all of the stations.

Cyperus ferruginescens Boeck. At most of the river stations.

Cyperus flavescens L. L1.

Cyperus pseudovegetus Steud. Known from only a few areas.

Cyperus rivularis Kunth. L4.

Cyperus strigosus L. At all of the river stations.

Eleocharis acicularis (L.) Roem. and Schultes. L1, L2, L3; S2.

Eleocharis elliptica Kunth var. *compressa* Drapalik and Mohlenbrock. Hardin and Jackson Counties.

Eleocharis elliptica Kunth var. *elliptica*. Along rivers and streams, Alexander, Gallatin, and Jackson Counties.

Eleocharis erythropoda Steud. Known only from Massac County.

Eleocharis obtusa (Willd.) Schultes in Roem. and Schultes var. *detonsa* (A. Gray) Drapalik and Mohlenbrock.

Eleocharis obtusa (Willd.) Schultes in Roem. and Schultes var. *obtusa*. In most moist situations.

Eleocharis obtusa (Willd.) Schultes in Roem. and Schultes var. *ovata* (Roth) Drapalik and Mohlenbrock. Roadside ditch along Route 3 near Howardton, Jackson County.

Eleocharis palustris (L.) Roem. and Schultes. Known only along a roadside ditch, Route 3, Jackson and Alexander Counties.

Eleocharis quadrangulata (Michx.) Roem. and Schultes. L2; also Country Club Lake, Sparta, Randolph County and a temporary pond in Alexander County.

Eleocharis tenuis (Willd.) Schultes var. *verrucosa* Svenson. Common at all the stations.

Eleocharis wolfii (A. Gray) Patterson. Saline County.

Fimbristylis autumnalis (L.) Roem. and Schultes. At all of the river stations and a few of the lake stations.

Hemicarpha micrantha (Vahl) Pax in Engler. R3, R4.

Rhynchospora capitellata (Michx.) Vahl. Known only from along Bay Creek, Belle Smith Springs, Pope County.

Rhynchospora corniculata (Lam.) A. Gray. S1.

Scirpus acutus Muhl. ex Bigel. L2.

Scirpus americanus Pers. L1, L2.

Scirpus atrovirens Willd. In all the aquatic situations; includes var. *georgianus* (Harper) Fern.

Scirpus cyperinus (L.) Kunth. In most aquatic situations.

Scirpus fluviatilis (Torr.) A. Gray. Known only from the Country Club Lake, Sparta, Randolph County.

Scirpus rubricosus Fern. In a few of the aquatic situations, particularly near lakes.

Scirpus lineatus Michx. At most of the stations.

Scirpus polyphyllus Vahl. Swampy woods of Pope and Massac Counties.

Scirpus purshianus Fern. L4.

Scirpus validus Vahl. S1, S2.

ARACEAE NECKER

Acorus calamus L. L3, L4; S2.

Peltandra virginica (L.) Kunth. S1, S2.

LEMNACEAE DUMORT.

Lemna minor L. S2; also a number of temporary ponds in Jackson and Union Counties.

Lemna perpusilla Torr. S2; also a swampy woods in Alexander County.

Lemna trisulca L. S2.

Lemna valdiviana Phil. S2; also Lester Swamp in western Jackson County.

Spirodela polyrrhiza (L.) Schleid. L1, L3; S2.

Wolffia columbiana Karst. L3.

Wolffia papulifera C. H. Thompson. S2.

Wolffia punctata Griseb. L3.

Wolffiella floridana (J. D. Sm.) C. H. Thompson. S2; also a strip mine pond in Perry County.

PONTEDERIACEAE RUIZ AND PAVON

Heteranthera reniformis Ruiz and Pavon. S2.

Pontederia cordata L. S2.

JUNCACEAE (VENT.) DUMORT.

Juncus acuminatus Michx. L1, L2, L3, L4.

Juncus biflorus Ell. R3.

Juncus brachycarpus Engelm. L1, L2, L4.

Juncus canadensis J. Gay ex Laharpe. S2.

Juncus effusus L. In most of the aquatic situations.

Juncus marginatus Rostk. L4; also along Route 3, Jackson County.

Juncus nodatus Coville. L2, L4.

Juncus torreyi Coville. In wet roadside ditches.

AMARYLLIDACEAE LINDLEY

Hymenocallis occidentalis (LeConte) Kunth. Low, swampy woods.

IRIDACEAE LINDLEY

Iris brevicaulis Raf. Low, swampy woods.

Iris fulva Ker. S1, S2.

Iris shrevei Small. At most of the stations.

ORCHIDACEAE LINDLEY

Habenaria peramoena A. Gray. Low, swampy woods.

Spiranthes cernua (L.) Rich. Low, swamp woods.

SAURURACEAE LINDLEY

Saururus cernuus L. In several of the aquatic situations.

SALICACEAE HORAN.

Populus deltoides Marsh. Common along rivers and streams.

Populus heterophylla L. In several of the aquatic situations.

Salix amygdaloides Anders. R3, R6, R7.

Salix caroliniana Michx. Around a lake, DuQuoin, Perry County.

Salix interior Rowlee. Along all the rivers and streams.

Salix nigra Marsh. At all of the stations.

Salix rigida Muhl. Along the Mississippi River near Cora, Jackson County.

Salix sericea Marsh. Along a few of the streams.

JUGLANDACEAE HORAN.

Carya aquatica (Michx. f.) Nutt. S1.

BETULACEAE AGARDH

Alnus serrulata (Ait.) Willd. Along clear streams, chiefly in the southeastern counties.

Betula nigra L. Along the rivers and streams.

FAGACEAE A. BR. EX ASCHERS.

Quercus lyrata Walt. Low, swampy woods; frequent along rivers.

Quercus michauxii Nutt. Along most of the rivers and streams.

Quercus palustris Muench. Along all of the rivers and streams.

Quercus phellos L. S1.

ULMACEAE MIRBEL

Celtis laevigata Willd. Along most of the streams and in the swamps.

Celtis occidentalis L. Along streams throughout southern Illinois.

Planera aquatica (Walt.) J. F. Gmelin. S1.

URTICACEAE REICHENB.

Pilea opaca (Lunell) Rydb. Low, swampy ground in extreme southwestern Jackson County.

Pilea pumila (L.) A. Gray. Low, moist ground throughout the area.

Urtica chamaedryoides Pursh. Low, swampy ground in Alexander and Jackson Counties.

ARISTOLOCHIACEAE JUSS. EX BLUME

Aristolochia nashii Kearney. S1.

POLYGONACEAE HORAN.

Brunnichia cirrhosa Banks ex Gaertn. S1.

Polygonum coccineum Muhl. ex Willd. S2.
Polygonum hydropiper L. In most of the aquatic situations.

Polygonum hydropiperoides Michx. In all of the aquatic situations.

Polygonum lapathifolium L. In all of the aquatic situations.

Polygonum opelousanum Riddell ex Small. S1, S2.

Polygonum pennsylvanicum L. In all of the aquatic situations.

Polygonum punctatum Ell. In all of the aquatic situations.

Polygonum sagittatum L. S2.

Polygonum selaceum Baldw. ex Ell. S1, S2.

Rumex fueginus Phil. R1; S2.

Rumex verticillatus L. In most of the aquatic situations.

CHENOPODIACEAE DUMORT.

Cycloloma atriplicifolium (Spreng.) Coult. R3, R4.

AMARANTHACEAE J. ST. HIL.

Acnida altissima (Riddell) Riddell ex Moq. Along all the rivers and most of the streams.

Acnida subnuda (S. Wats.) Standl. R3, R4, R5.

Acnida tamariscina (Nutt.) Wood. R6, R7.

RANUNCULACEAE JUSS.

Clematis crispa L. S1.

Ranunculus flabellaris Raf. ex Bigel. S1, S2.
Ranunculus laxicaulis (Torr. & Gray) Darby. S2.

Ranunculus pusillus Poir. ex Lam. S2.

Ranunculus septentrionalis Poir. in Lam. In low, swampy woods.

CABOMBACEAE A. GRAY

Brasenia schreberi Gmel. S1; also Lake Moses, Benton, Franklin County.

Cabomba caroliniana A. Gray. S2.

NELUMBONACEAE LINDLEY EX SMALL

Nelumbo lutea (Willd.) Pers. In most of the lakes and swamps.

NYMPHAEACEAE DC.

Nuphar advena (Ait.) Ait. f. In most of the lakes and swamps.

Nymphaea odorata Ait. S1, S2.

CERATOPHYLLACEAE A. GRAY

Ceratophyllum demersum L. In several of the local ponds.

CRUCIFERAE JUSS.

- Cardamine arenicola* Britt. Low, wet woods.
Cardamine bulbosa (Schreb.) BSP. Low, wet woods.
Cardamine pennsylvanica Muhl. ex Willd. Low, wet woods.
Nasturtium officinale R. Br. S2.
Neobeckia aquatica (A. Eaton) Greene. S2.
Rorippa islandica (Oeder) Borbas. In most of the aquatic situations.
Rorippa sessiliflora (Nutt.) Hitchc. Along many of the rivers and streams.
Rorippa sinuata (Nutt.) Hitchc. Along the banks of the Ohio River in Pope and Massac Counties.

CRASSULACEAE DC. IN LAM. AND DC.

- Penthorum sedoides* L. In most of the aquatic situations.

ESCALLONIACEAE DUMORT.

- Itea virginica* L. S1, S2.

HAMAMELIDACEAE LINDLEY

- Liquidambar styraciflua* L. Low, wet woods.

PLATANACEAE LINDLEY

- Platanus occidentalis* L. Along all the rivers and streams.

ROSACEAE B. JUSS.

- Potentilla monspeliensis* L. Along rivers and streams.
Potentilla paradoxa Nutt. ex Torr. & Gray. R3.
Rosa palustris Marsh. S1, S2.

LEGUMINOSAE P. F. GMEL.

- Gleditsia aquatica* Marsh. S1, S2.
Gleditsia triacanthos L. In many of the aquatic situations.
Psoralea onobrychis Nutt. Along Big Muddy River, Jackson County.
Sesbania exaltata (Raf.) Cory. Along Ohio River, Pulaski County. Adventive.
Wisteria macrostachya (Torr. & Gray) Robins. & Fern. in A. Gray. S1.

LINACEAE DUMORT.

- Linum striatum* Walt. Along streams in Jackson, Johnson, and Pope Counties.

BALSAMINACEAE DUMORT.

- Impatiens biflora* Walt. In low, wet woods.
Impatiens pallida Nutt. In low, wet woods.

EUPHORBIACEAE J. ST. HIL.

- Chamaesyce geyeri* (Engelm.) Small. R4.
Chamaesyce humistrata (Engelm.) Small. R3, R4, R6.

- Chamaesyce serpens* (HBK.) Small. R3, R4.
Tragia cordata Michx. Along Ohio River, Pope County.

CELASTRACEAE LINDLEY

- Euonymus americanus* L. S1.

AQUIFOLIACEAE (DC.) RICH.

- Ilex decidua* Walt. In many aquatic situations.

ACERACEAE J. ST. HIL.

- Acer drummondii* Hooker & Arnott. S1, S2.
Acer negundo L. Frequent along streams and rivers.
Acer rubrum L. In all moist situations.
Acer saccharinum L. Along all rivers and streams.

VITACEAE LINDLEY

- Ampelopsis arborea* (L.) Koehne. Along rivers in the southwestern counties.
Vitis aestivalis Michx. Along rivers and streams.
Vitis cinerea Engelm. ex Millardet. Along rivers and streams.

MALVACEAE NECKER

- Hibiscus lasiocarpus* Cav. In most of the aquatic situations.
Hibiscus militaris Cav. L2; S1, S2.
Hibiscus moscheutos L. L2.

HYPERICACEAE LINDLEY

- Hypericum mutilum* L. Along most of the rivers and streams.
Hypericum prolificum L. Along rocky streams.
Triadenum tubulosum (Walt.) Gleason. S1.
Triadenum walteri (Gmel.) Gleason. S1, S2.

LYTHRACEAE LINDLEY

- Ammannia coccinea* Rottb. In all aquatic situations.
Decodon verticillatus (L.) Ell. S1, S2.
Peplis diandra Nutt. ex DC. S2.
Rotala ramosior (L.) Koehne. In most of the aquatic situations.

ONAGRACEAE DUMORT.

- Epilobium coloratum* Muhl. ex Willd. R5.
Jussiaea decurrens (Walt.) DC. S1, S2.
Jussiaea diffusa Forskal. In most ponds and lakes.
Jussiaea leptocarpa Nutt. R3, R6.
Ludwigia alternifolia L. R4, R5, R6; S1, S2.
Ludwigia glandulosa Walt. S1.
Ludwigia palustris (L.) Ell. Along all rivers and streams.
Ludwigia polycarpa Short & Peter. S1.

HALORAGACEAE HORAN.

- Myriophyllum heterophyllum* Michx. The "Lagoon," Riverside Park, Murphysboro.
Myriophyllum pinnatum (Walt.) BSP. Country Club Lake, Sparta, Randolph County.
Myriophyllum verticillatum L. L3.
Proserpinaca palustris L. S1, S2.

CALLITRICHACEAE LINDLEY

- Callitriche heterophylla* Pursh. S1, S2.
Callitriche palustris L. S1, S2.

NYSSACEAE ENDL.

- Nyssa aquatica* L. S1.

UMBELLIFERAE SCOP.

- Cicuta maculata* L. In many moist situations.
Heracleum lanatum Michx. Along streams, Jackson and Pope Counties.
Oxypolis rigidior (L.) Raf. S1.
Ptilimnium costatum (Ell.) Raf. L3; S1, S2.
Ptilimnium nuttallii (DC.) Britton. In a swampy area near Makanda, Jackson County.
Sium suave Walt. L3; S1, S2.

STYRACACEAE A. DC. IN DC.

- Styrax americana* Lam. S1.

PRIMULACEAE VENT.

- Hottonia inflata* Ell. S1, S2.
Lysimachia ciliata L. Along most of our streams.
Lysimachia nummularia L. In numerous aquatic situations. Adventive.
Samolus parviflorus Raf. In moist soil throughout southern Illinois.

OLEACEAE POIR. IN LAM.

- Forestiera acuminata* (Michx.) Poir. Along rivers and streams and in swamps.
Fraxinus pennsylvanica Marsh. Low, swampy ground.
Fraxinus tomentosa Michx. f. Low, swampy ground; often in swamps.

APOCYNACEAE LINDLEY

- Trachelospermum difforme* (Walt.) A. Gray. S1.

ASCLEPIADACEAE LINDLEY

- Asclepias incarnata* L. In most aquatic situations.
Asclepias perennis Walt. In low woods; often in swamps.

CONVOLVULACEAE VENT.

- Cuscuta compacta* Engelm. S2.

HYDROPHYLLACEAE LINDLEY

- Hydrolea affinis* A. Gray. S1, S2.

VERBENACEAE JUSS.

- Phyla lanceolata* (Michx.) Greene. In most aquatic situations.

LABIATAE B. JUSS.

- Lycopus americanus* Muhl. ex Bart. In most moist situations.
Lycopus rubellus Moench. S1, S2.
Lycopus virginicus L. In nearly all the aquatic situations.
Scutellaria lateriflora L. Along rivers and streams.
Teucrium canadense L. Moist soil throughout southern Illinois.

SCROPHULARIACEAE LINDLEY

- Bacopa rotundifolia* (Michx.) Wettst. in Engler & Prantl. In a few of our ponds and streams.
Chelone glabra L. Low, wet ground.
Chelone obliqua L. Low, wet ground.
Gerardia tenuifolia Vahl. Along all the rivers.
Gratiola neglecta Torr. In all aquatic situations.
Gratiola virginiana L. Around lakes and in swamps.
Leucospora multifida (Michx.) Nutt. Along most rivers and streams.
Lindernia anagallidea (Michx.) Pennell. In all aquatic situations.
Lindernia dubia (L.) Pennell. In all aquatic situations.
Mimulus alatus Ait. In nearly all moist situations.
Mimulus ringens L. R7.

ACANTHACEAE J. ST. HIL.

- Dianthera americana* L. In a variety of aquatic situations.
Dianthera lanceolata (Chapm.) Small. S1.

LENTIBULARIACEAE LINDLEY

- Utricularia gibba* L. L2; S2.
Utricularia vulgaris L. S2.

RUBIACEAE B. JUSS.

- Cephalanthus occidentalis* L. In all aquatic situations.
Diodia virginiana L. R3, R6.
Galium obtusum Bigel. Wet soil throughout southern Illinois.
Galium triflorum Michx. S2.
Spermacoce glabra Michx. In many moist situations.

LOBELIACEAE JUSS.

- Lobelia cardinalis* L. Wet, swampy ground.
Lobelia puberula Michx. Wet ground, mostly along streams.
Lobelia siphilitica L. Wet ground, mostly along streams.

VALERIANACEAE BATSCH.

- Valerianella radiata* (L.) Durf. At all the aquatic stations.

COMPOSITAE P. F. GMEL.

- Artemisia gnaphalodes* Nutt. Along Ohio River, Pope County. Adventive.
Aster laevis L. R3, R4.
Aster ontariensis Wieg. R3, R4.
Aster praealtus Poir. in Lam. In most of the river and stream situations.
Aster simplex Willd. R5.
Bidens aristosa (Michx.) Britt. Common in all moist areas.
Bidens cernua L. R5.
Bidens comosa (A. Gray) Wieg. Wet ditch west of Ware, Union County.
Bidens connata Muhl. ex Willd. S2.
Bidens coronata (L.) Britt. L2.
Bidens discoidea (Torr. & Gray) Britt. S2: also Snyder's Lake, Jackson County.

- Bidens frondosa* L. S2; also a strip mine pond near Cambria, Williamson County.
Bidens polylepis Blake. S2.
Bidens vulgata Greene. L1; S2.
Eclipta alba (L.) Hassk. In all aquatic situations.
Eupatorium altissimum L. R3, R4, R5.
Eupatorium coelestinum L. In a variety of aquatic situations.
Eupatorium fistulosum Barratt. Low, swampy ground near Olive Branch, Alexander County.
Eupatorium maculatum L. Along streams.
Eupatorium perfoliatum L. S1.
Helenium autumnale L. R4, R5.
Melanthra hastata (Walt.) Michx. R7.
Mikania scandens (L.) Willd. S1.
Pluchea camphorata (L.) DC. In most of the aquatic situations.
Senecio aureus L. In a few aquatic situations.
Senecio glabellus Poir. in Lam. Common along rivers and streams.
Solidago patula Muhl. ex Willd. L2.
Solidago rugosa Mill. L1.
Xanthium chinense Mill. Common along rivers.
Xanthium commune Britt. R3.

REFERENCES

- Bell, R. 1956. Aquatic and marginal vegetation of strip mine waters in southern Illinois. Trans. Ill. Acad. 48: 85-91.
 Bollwinkel, C. W. 1958. Sink-hole pond vegetation of southern Illinois. Masters thesis, Southern Illinois University, Carbondale (Unpublished).
 Brewer, R. and E. D. Triner. 1956. Vegetational features of some strip mined land in Perry County, Illinois. Trans. Ill. Acad. 48: 73-84.
 Hankla, D. J. 1950. Aquatic vegetation of Crab Orchard Lake and its utilization as food by waterfowl. Masters thesis, Southern Illinois University, Carbondale (Unpublished).
 Mohlenbrock, R. H. 1959. A floristic study of a southern Illinois swampy area. Ohio J. Sci. 59: 89-100.

INHERITANCE OF BLACK HAIR PATTERNS IN CATTLE LACKING THE EXTENSION FACTOR FOR BLACK (E). IV. PARTITIONING PHENOTYPES BY CASTRATION²

L. O. GILMORE, N. S. FECHHEIMER, AND C. S. BALDWIN¹

Department of Dairy Science, Ohio Agricultural Experiment Station, Wooster

The appearance of blackish hairs in genetically red cattle (Jerseys and Ayrshires) was shown by Baldwin et al. (1954) to be affected by genotype, sex, and age. They pointed out that the areas on which these hairs are found under

¹Present address, Central Ohio Breeding Association, Columbus.

²Journal Article No. 57-61, The Ohio Agricultural Experiment Station.

different conditions are eye, cheek, muzzle, ear, neck, shoulder, body, rump, legs, and switch. They differentiated between blackish and black hairs, microscopically, and showed that the frequency with which blackish hairs were found was different for various parts of the body. It was concluded that the presence of blackish hairs on the head depended on the presence of the *Bs* gene. Those on the body and rump were concluded to depend on a pattern modifier, *Bp_m*, which exhibited sexual dimorphism in heterozygotes (Baldwin et al., 1956). A trait characterized as exhibiting sexually dimorphic reversal of dominance is also known as sex-influenced.

Pattern baldness in man has been shown to be caused by a sex-influenced gene (Snyder and Yingling, 1935). When Hamilton (1942, 1948) studied this character in eunuch, eunuchoid, and castrate males, he was unable to detect the appearance of baldness. When, however, testosterone therapy was applied to four castrated men, patterned baldness began to appear; when the therapy was halted the progression of the baldness ceased. Other sex-influenced traits reviewed by Baldwin are scurs and a certain type of horns (African) in both sheep and cattle.

That *Bp_m* is a modifier of *Bs* has been questioned by Overton et al. (1958) who analyzed the data of Baldwin (1951) by a method of maximum likelihood to test the validity of assuming that the variations observed could be explained also by the action of three alleles, i.e., *Bs_m*, *Bs* and *bs*. Although they showed that an allelic hypothesis was also tenable for the Jersey data, it was rejected at the 5 per cent level of significance in the Ayrshire data.

TABLE 1
The effect of castration on the persistence of black hair patterns in Jersey males

Treatment	No. with Black Hair on Specified Areas					
	Head	Crest	Body	Leg	Switch	Ear
Before	16	15	14	12	12	2*
After	6	5	0	12	12	2

*Both had black fringe hairs.

Hancock (1952) concluded from the observations on nearly 300 sets of identical twins that *Bs* has the pleiotropic effect of producing a strip of brown on the generally black skin extending from the lower jaw along the ventral line to the analvulvar region and along the inside of the tail. There may be a break in the brown skin under the neck. The inner surface of the ear as well as the lower portion of the outer surface is also brown skinned. Hancock found that there frequently occurred a characteristically shaped black pigmented area on the brown skin inside the ear (ear streak) and on the ano-vulvar region (a-v spot). The bilateral symmetry of the whole of this skin color pattern was so marked and the concordance between identical twins so great as to warrant the conclusion that all variations except those resulting from conditions of housing and lactation must be explained genetically. In a further effort to explain different genetic causes for the black hairs on red cattle, Hancock proposed the existence of a third gene, a simple recessive, *be*, which, in homozygotes, possessing also the *Bs* gene differs from *Be - Bs*—cattle by having only the skin of the udder, belly, brisket and the upper two-thirds of the inner surface of the ears brown while the rest is black. No intratwin pair differences were found with respect to the phenotypes of *be be* animals. Because of the presumed interaction of *be be* and *Bs*, the hair of the inner fringe of the ears is generally jet black.

After the observation by Baldwin (1956) that an Ayrshire freemartin, from parents both of which were nonblackish patterned, exhibited the pattern, the need to observe experimentally imposed castration effects was suggested. This was done on three Ayrshire bull calves. This experiment was concluded prematurely but, nevertheless, the blackish pattern on one of the bulls disappeared. The purpose of this paper is to report further pertinent observations that were made on 17 Jersey males, some of which were castrated for another experiment (Hibbs et al., 1959).

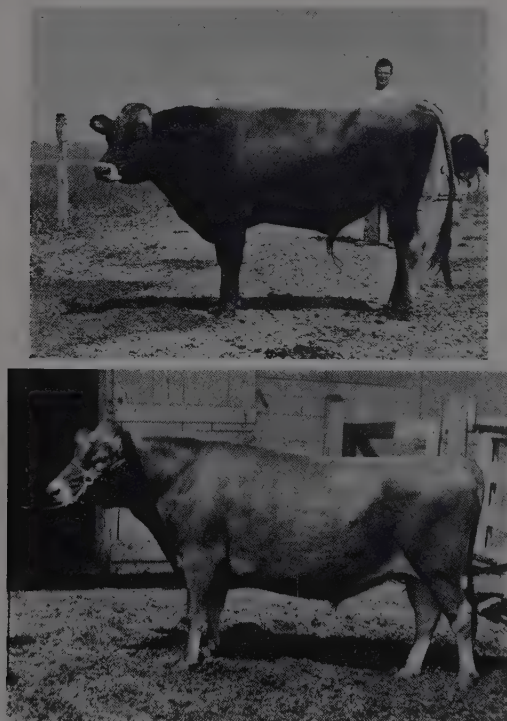


FIGURE 1. The blackish pattern disappears with castration. A. (top) Jersey bull, 19½ mo. old. B. (bottom) Same male 11½ mo. after castration, at 40½ mo. of age. The blackish pattern had completely disappeared.

EXPERIMENTAL PROCEDURE

Thirteen of the 17 calves were castrated at approximately six months of age by crushing the external pudic nerves and arteries with an emasculator. Before castration and again at approximately 17 months, color slides were taken of each side of each animal. The other four bulls were castrated at an older age by gonadectomy, three at 11 months, and one at 23 months. These four were observed carefully as well as photographed at various times before and after castration.

From each photograph, or animal, information regarding the presence of black hairs on the head, ears, crest, body, legs, and switch was recorded.

RESULTS AND DISCUSSION

From the observations summarized in table 1, it is seen that the six areas studied can be divided into two separate categories, i.e., those areas which were uniformly unchanged by castration and those areas affected at least in some of the cases. In no case was there a change in the gross nature or the extent of the black hairs appearing on the tail and legs. From this it is concluded that the color expression of the black hairs in these areas are influenced by genes, the expression of which is not affected by sex hormones. While the same result was observed on the black hairs of the ears as on the legs and switch, there was an insufficient number of cases to justify a firm conclusion. Only two possessed the black hair fringe on the ear described by Hancock (1952) as caused by the interaction of *Bs* with the *be be* genotype. In neither case, however, was a change noted in the appearance of the black hair fringe following castration.

From the observations made in this study, there is corroboration of the conclusion by Baldwin (1951) that the black hairs in the switch and on the legs are present at birth. Furthermore, it has been shown that the pattern of black hairs on the switch and distal part of the leg is not modified by brindling as are other areas of the body on which blackish hairs are found (Baldwin et al., 1954).

It has been observed that blackish hairs appear on the areas of the body other than legs and switch after approximately one month of age. The color expression may not be fully developed until 6 months or more in males and 2 to 3 years in females. The blackish hairs on the body (including rump and thigh) disappeared in all 14 cases in which it was present before castration (table 1, fig. 1). Thus, it appears that blackish pattern in cattle responds to male hormone withdrawal in the same manner as pattern baldness in man. For both head and crest, approximately one-third of the experimental subjects failed to lose the blackish hairs in each area; three failed in both areas. So far the relation between *Bs*, *Bp_m*, and *be* with different hormone levels has not been investigated with respect to either of these areas; neither has the possibility of a differential response to castration between the homozygote and heterozygote been excluded. It was impossible in the present material to make a satisfactory diagnosis of genotype from the pedigrees and no definitive matings were made.

SUMMARY AND CONCLUSIONS

Seventeen Jersey bulls were castrated after they became old enough to show blackish hairs on the head, ears, crest, body, legs, and switch. Within one year from the period of castration blackish hairs disappeared from the body, rump and thigh areas in all 14 animals showing pre-castration blackish in these areas. This is interpreted to indicate absolute dependence of *Bp_m* on the male hormone for its expression. In 10 out of 16 cases the blackish hairs of the head disappeared, indicating either a partial reliance of *Bs* on the male sex hormone, incomplete dominance or an interaction between hormonal function and the *Bs* alleles. A similar result for blackish or black hairs on the crest suggests the need for investigating the cause of their appearance in this area. In no case did black hairs disappear from the leg or switch. This is interpreted to indicate that these may be black instead of blackish hairs and that a separate genetic cause is responsible for their appearance.

REFERENCES

- Baldwin, C. S. 1951. Sex-Influenced Color Inheritance in Cattle. Master's Thesis. The Ohio State University.
—, L. O. Gilmore, and N. S. Fechheimer. 1954. Inheritance of black hair patterns in cattle lacking the extension factor for black (E). I. Blackish. J. Dairy Sci. 37: 1368-1375.
—, —, —, and D. C. Rife. 1956. Inheritance of black hair patterns in cattle lacking the extension factor for black (E). II. Blackish pattern. J. Dairy Sci. 39: 435-439.
Hamilton, J. B. 1942. Male hormone stimulation is prerequisite and incitant in common baldness. Amer. J. Anat. 71: 451-480.

- . 1948. The role of testicular secretions as indicated by the effects of castration in man and by pathological conditions and the short life span associated with maleness. Recent Ad. Hormone Res. 3: 252-322.
- Hancock, J. 1952. Identical cattle twins and colour inheritance. Endeavour 11: 78-86.
- Hibbs, J. W., E. W. Klosterman, and H. R. Conrad. 1959. Dairy beef production. Part 1. Performance of dairy steers from birth to slaughter. Ohio Agr. Expt. Sta. Bull. 833.
- Overton, Louise F., R. Laird, and N. S. Fechheimer. 1958. Inheritance of black hair patterns in cattle lacking the extension factor for black (E). III. A multiple allelic hypothesis to explain the inheritance of blackish and blackish pattern. Ohio J. Sci. 58: 133-139.
- Snyder, L. H. and H. C. Yingling. 1935. The application of the gene-frequency method of analysis to sex-influenced factors with special reference to baldness. Human Biol. 7: 608-615.

RECORDS OF SNOW FLEAS (*COLLEMBOLA*) FROM NORTHEASTERN OHIO

RALPH W. DEXTER

Department of Biology, Kent State University, Kent, Ohio

Insects of the order *Collembola*, known commonly as Snow Fleas, have seldom been studied in Ohio. These insects are sporadic in both time of appearance and in distribution, so that all field records are of interest and value. In recent years several collections have come to my attention, and these are placed on record here. Acknowledgment is made to Dr. Harlow B. Mills, Chief of the Illinois State Natural History Survey, for identification of these specimens and for a critical reading of the manuscript.

Snow Fleas are usually found only in late winter and early spring when they cluster in great numbers on the surface of the snow. Folsom (1902) recognized three species of true Snow Fleas: *Achorutes nivicola* Fitch, and two species described by him as new: *A. packardii* and *A. harveyi*. All three had been reported in the literature previously as *A. nivicola*. Folsom (1916) listed *A. packardii* from Salem, Ohio, collected by A. D. MacGillivray. This is the only published Ohio record known to me. The more common species, *A. nivicola*, has never been reported from Ohio, although it seems reasonable that this should be commonly found in the state. Three locality records have been established by the present study.

On 9 February 1954, a large mass of Snow Fleas was found on a fresh bank of snow at the pumping station of the Akron Water Works near Twin Lakes. This is situated in Portage County, some 3 miles northeast of Kent. These insects formed a large, black patch, conspicuous on the white background and were on the north-facing slope of a railroad bank. Many specimens were collected by John Gettrust, superintendent, and Jack Olson, chemist, at the water works. Some were kept alive for about a week, being fed on banana. Three days after the original collection, 2 in. of fresh snow covered the ground and further specimens could not be found. Some 10 weeks later on April 22, Snow Fleas appeared again in great abundance. One day later, only a few remained and these were floating on puddles formed by heavy rains. Specimens have not been collected at that location since that time. Dr. H. B. Mills identified the specimens as *Achorutes nivicola* Fitch, now known as *Hypogastrura nivicola* (Fitch). (See Mills, 1934; and Maynard, 1951, for an account of this species.)

On 23 February 1954, Snow Fleas were also collected in large numbers at the residence of Mr. and Mrs. Baughman in Canal Fulton in Stark County. They were found on the snow in great abundance, against the foundation of the house. After three days they disappeared. They had not been seen before, nor reported to me since that time. Dr. Mills identified specimens as belonging to Hypogastrura, resembling *H. sahlbergi* Reuter. This European species has not previously been recorded from North America. Dr. Mills wrote (personal communication), "The presence of European forms in this country is to be expected and we are constantly running into them. It is probable that many of them are not recent introductions for the proportion of Holarctic forms is extremely high in this group." Dr. Mills is planning further study on these specimens for precise identification.

During 11-14 February 1955, Snow Fleas were found near Uniontown, also in Stark County. They were found in abundance around the foundation of a house and a cold frame on a farm southwest of Uniontown. Specimens were collected by Mrs. James Jarret. After the disappearance of the snow, specimens were found for a short while on the lower limbs of lilac bushes and in depressions in the ground. These were identified by Dr. Mills as *H. nivicola*. At the same time these specimens were collected, some other Snow Fleas were observed, but not collected, about a half mile away, where they were found in a corn field. Unfortunately, specimens were not available for identification. On 2 March 1957, Mrs. Jarret found specimens again on fresh snow in a huckleberry swamp some 30 yd behind her house.

Snow Fleas seem to appear primarily at times when the ground is snow-covered, the sun is shining brightly, and the temperature is just above freezing (Melnichenko, 1935; Chapman, 1954). Macnamara (1919) observed that, "As a rule they do not appear until the thermometer approaches 25° F, and from 30° F upwards they reach their greatest abundance." Snow is not necessary for their emergence from the ground, but it is during the presence of snow that these insects are easily detected and most records have been made under such a condition. Hence the name "snow fleas." Folsom (1901) believed these insects are distributed primarily by streams which form from melting snow, although man undoubtedly also transports them through products of agriculture.

Maynard (1951) regarded the common Snow Flea as a member of Hypogastrura, and recently the genus *Achorutes* has been suppressed (Opinion 435, Internat. Comm. on Zool. Nomen, 1956). Accordingly, the Snow Fleas should now be placed in the genus Hypogastrura, and the common species reported here should now be listed as *H. nivicola* (Fitch).

Snow Fleas (*Collembola*) are now known to occur in Ohio. Two localities in northeastern Ohio are the first to be reported for *Hypogastrura nivicola* (Fitch), and one record is given for a presumed European species *H. cf. sahlbergi* Reuter.

LITERATURE CITED

- Chapman, J. A. 1954. Observations on snow insects in western Montana. *Canad. Ent.* 86: 357-363.
- Folsom, J. W. 1901. The distribution of Holarctic Collembola. *Psyche* 9: 159-162.
- . 1902. The identity of the snow flea (*Achorutes nivicola* Fitch). *Psyche* 9: 315-321.
- . 1916. North American collembolous insects of the subfamilies Achorutinae, Neanurinae, and Podurinae. *Proc. U. S. Nat. Mus.* 50: 477-525.
- International Commission on Zoological Nomenclature. 1956. *Bull. Zool. Nomen.* (Opinion 435). 14 (pt. 21): 425-458.
- Macnamara, C. 1919. Remarks on Collembola. *Canad. Ent.* 51: 265-271.
- Maynard, E. A. 1951. A monograph of the Collembola or springtail insects of New York State. Comstock Publishing Co. 339 pp.
- Melnichenko, A. N. 1935. Periodic appearance of Collembola on the snow. *Prob. Ecol. and Biocenol.* 2: 210-220.
- Mills, H. B. 1934. A monograph of the Collembola of Iowa. Collegiate Press. 143 pp.

AN ECOLOGICAL NOTE ON THE MICROCLIMATE OF THREE SPECIES OF ANTS*

ROBERT E. WILLIAMS

Department of Zoology and Entomology, The Ohio State University, Columbus 10

This field study was conducted in a small valley in Hocking County, called Neotoma Valley.

SPECIES OBSERVED

Formica exsectoides Forel.—This is a pugnacious species, rushing from its nest at the slightest provocation to bite and eject formic acid into the wound inflicted. Its nest was mounded against a utility pole located on the valley floor (fig. 1). The nest was exposed to full sunlight except for the periods when the sun was behind one or the other of two ridges which border the valley, their longitudinal axes running northwest and southeast.

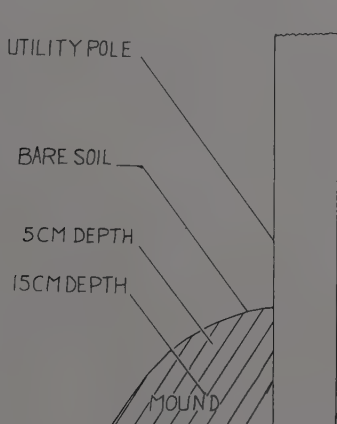


FIGURE 1. Diagrammatic sketch of the nest location of *Formica exsectoides* Forel.

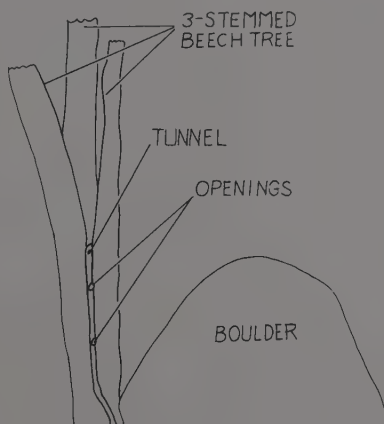


FIGURE 2. Diagrammatic sketch of the nest location of *Camponotus ferrugineus* (Fab.).

Camponotus ferrugineus (Fabricius).—This species belongs to the "dairy farmer" type. Its nest was located on the Mixed-Oak or southwest facing slope in the soil underneath a huge Blackhand sandstone boulder. An earthen tunnel led from the soil underneath the boulder up a three-stemmed beech tree to a height of about 60 cm (fig. 2). There were two openings in the tunnel, the first about 20 cm from the ground level, the other about 20 cm above the first. These openings were used by the ants when taking unidentified species of aphid out to "pasture" on the beech tree, usually to an area very near the tunnel.

Lasius nearcticus Wheeler.—This is a very small, pale yellow form with degenerate eyes, rather secretive, and seldom seen above ground during the day. Its nest was about 5 cm down in the soil on the Mixed-Mesophytic or northeast facing slope (fig. 3).

*Supported by a National Science Foundation Summer Grant.

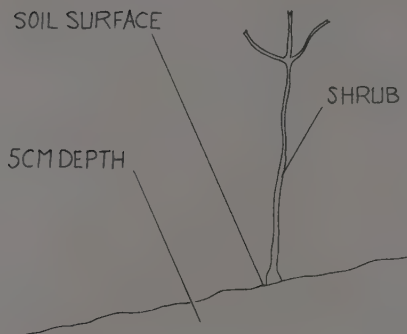


FIGURE 3. Diagrammatic sketch of the nest location of *Lasius nearcticus* Wheeler.

METHODS, EQUIPMENT, PROCEDURES

A series of temperature measurements was taken in and around the nests during the months of August and September, 1959. Temperatures were recorded by using a Leeds-Northrup portable potentiometer with copper-constantan leads, operated by a dry cell battery, and a Leeds-Northrup Speedomax strip-chart recorder.

The work with *Camponotus* was terminated at the end of August as a result of a heavy rain which destroyed the tunnel. Nest temperatures for this species were not taken because of the inaccessibility of the nest under the boulder, and the uncertainty of knowing whether the thermocouple junction was in the nest proper or only at its periphery. The temperature measurements were taken at the following places:

For *Camponotus ferrugineus*

1. *Air temperature*: 30 cm laterally from and on a level with the first opening in the tunnel.
2. *Surface*: 1 mm away from the bark of the beech tree adjacent to an area where the ants pastured the aphids.
3. *Inside the tunnel*: Between the lower and upper openings.
4. *In the soil*: 15 cm in depth.

For *Formica exsectoides*

1. *Air temperature*: 30 cm laterally from the nest, about 20 cm above the soil.
2. *Surface*: 1 mm above the bare soil of the mound.
3. *In the soil*: Inside the mound at 5 and 15 cm depths respectively.

For *Lasius nearcticus*

This is not a mound- or external edifice-building species. There is in practice no apparent evidence of the ants' working environment being commonly above ground. Measurements of the soil surface and air temperature therefore seemed unwarranted. The pale yellow color and the degenerate eyes indicate that the species is predominantly soil inhabiting or nocturnally active, or both.

In view of the above consideration, the temperature was recorded only at a point 5 cm inside the nest.

DISCUSSION

The data (table 1) are grouped to illustrate the variation in temperature between each ecologically corresponding area of each habitat of a given species

with either of the other two species, and to give an indication of the variation in temperature between each area of a given habitat for that particular species.

There may be an objection that temperatures inside the tunnel of *Camponotus* should not be compared with the 5 cm soil temperature of *Formica* and *Lasius*. However, they are ecologically equivalent. As stated previously, the 15 cm soil area temperature of *Camponotus* was not recorded due to the presence of the boulder. The figures given are soil temperatures representative of the Mixed-Oak community at the depths in which the nests were located.

TABLE 1
Temperature recordings—1959

Date	Valley Floor <i>Formica exsectoides</i>				Mixed Mesophytic <i>Lasius nearcticus</i>	Mixed-Oak Community <i>Camponotus ferrugineus</i>			
	Air	Surface	5 cm in soil	15 cm in soil	5 cm in soil	Air	Surface	Inside Tunnel	15 cm in soil
Aug. 1	87	110	82	70	72	75	72	70	67
2	72	106	80	70	73	77	73	68	66
3	72	98	77	72	70	73	70	70	67
4	78	102	79	70	—	75	73	70	66
6	83	118	84	75	—	77	73	70	66
7	94	126	86	77	—	81	75	70	67
8	75	88	81	70	68	72	72	70	67
10	84	124	88	70	72	79	72	70	67
11	84	127	86	70	69	77	73	68	66
12	88	126	91	79	72	86	81	70	66
13	79	91	91	82	68	80	77	73	66
14	84	122	90	79	69	84	77	70	66
17	75	79	77	75	69	73	73	70	67
18	75	79	75	73	73	75	73	70	66
20	91	138	79	73	74	84	79	72	66
21	91	122	82	75	71	82	79	73	67
27	86	111	82	82	75	82	79	73	67
29	81	95	75	73	69	79	77	73	66
Sept. 1	81	108	75	72	72				
3	75	88	77	75	71				
5	75	86	84	84	68				
7	84	140	73	70	64				
8	86	128	80	76	67				
9	75	84	76	70	72				
11	88	136	81	73	73				
13	64	80	72	70	70				
14	64	72	68	66	70				
16	80	120	79	64	60				
19	70	91	66	63	60				
20	72	95	68	61	47				
21	67	78	74	65	53				
22	68	77	73	65	53				

The data indicate that *Camponotus ferrugineus* live and work in a very stable temperature environment. This environment is partially effected by the ameliorating influence of the Mixed-Oak community, and partially through the presence of the boulder. During the period from the fall of the leaves to the time the canopy closes at the end of spring the boulder receives the incident sun rays and is probably warmed considerably above the ambient temperatures. It would serve as a source of heat, or at least an effective insulator, thus playing an important role in the microclimate of this species.

It can be seen at once that in contrast to *Camponotus* in the Mixed-Oak community, *Formica* on the valley floor is subjected to some extremes in temperature and to some sharp variations in temperature. Visualize *Camponotus* going out to pasture its aphids on August 20, leaving an area where the temperature was 72° F and moving into one of 79° F. Yet on that same day, at almost the same moment *Formica* moved from an environment of 79° F to one of 138° F, while *Lasius* experienced a temperature of 74° over on the Mixed-Mesophytic slope. But, *Formica exsectoides* was seen day after day moving in and out of the nest tending to the business of ants, without any apparent impediment that might be consequential to so sudden and extreme temperature variations.

The data show that *Lasius nearcticus* is subjected to a temperature variation that is much less than that of either of the other two species, at least at the 5 cm soil level. Temperatures of the Mixed-Mesophytic community are characteristically less variable than those of the other two habitats (Wolfe, Wareham, Scofield, 1949). Whereas the less variable temperature of the microclimate of *L. nearcticus* may be partially accounted for by the location of its nest in this community, this stability of microclimate temperatures is probably more accurately attributed to the behavior of this species, i.e., a subsurface dweller.

Dr. Richard Gorham did a study of the ants in the vicinity of Oxford, Ohio, and collected this species only twice, noting in each instance that it was found in the soil around roots or rotted logs, in a Beech-Maple type forest (personal communication).

SUMMARY

It appears that during the month of September *Lasius nearcticus* lived in a cooler and less variable microclimate with respect to temperature than did *Formica exsectoides*. During the month of August the microclimatic temperature was cooler and less variable for the former species than for either *Formica exsectoides* or *Camponotus ferrugineus*. This difference is partly accounted for by the macroclimate in which its microclimate is found, namely the Mixed-Mesophytic community, and partly by the ant's inherited behavior, that of being a subsurface soil-dweller. It can be inferred that *L. nearcticus* would be more intolerant of high fluctuating temperatures than would either of the other two species of ants.

LITERATURE CITED

- Wolfe, J. N., R. T. Wareham, and H. T. Scofield. 1949. Microclimates and macroclimate of *Neotoma*, a small valley in central Ohio. Ohio Biol. Surv. 41: 267 pp.

Elements of Physics. George Shortley and Dudley Williams. Prentice-Hall, Inc. Englewood Cliffs, N. J. Third edition, 1961. 928 pp.

The very well received second edition has been extensively rewritten with the addition of many new problems for the student at the end of each chapter. The problems are on the whole somewhat harder than those of the previous editions. Additions in subject matter have been made also and are integrated into the elements of physics. A separate section on modern physics is therefore not needed. Calculus is emphasized more than previously. The five major topics of the book are 1) mechanics, 2) heat and molecular physics, 3) wave motion and sound, 4) light and 5) electricity and magnetism. These topics are covered in forty-three chapters. Ten useful tables make up the appendix.

Teachers of college physics who instruct serious second-year students that have had high-school physics and are enrolled in calculus, will be pleased with this third edition as a complete text for a one-year course in beginning college physics.

MARION POOL

AQUATIC FUNGI FROM SOUTH BASS AND NEIGHBORING ISLANDS IN WESTERN LAKE ERIE. I. UNIFLAGELLATE AND BIFLAGELLATE PHYCOMYCETES†

E. S. BENEKE AND J. A. SCHMITT

*Department of Botany and Plant Pathology, Michigan State University, East Lansing,
and Department of Botany and Plant Pathology, The Ohio State University, Columbus*

Recently Cooke and Bartsch (1960) pointed out the paucity of publications concerned with the occurrence of aquatic Phycomycetes in Ohio soil and streams. They cite only two other papers (Harvey, 1952; Cooke and Bartsch, 1959) which enumerate this group of Ohio fungi. Each of these papers investigated a possible relationship between polluted streams and the aquatic fungi occurring in them. Cooke and Bartsch (1960) report twenty-one species of biflagellate Phycomycetes and several sterile strains, one of which was an isolate of the genus *Allomyces*, from streams in southern Ohio. As nearly as can be determined from the literature, no attempts have been made to identify the aquatic fungus flora of the islands or waters of western Lake Erie.

The present paper is the first of a series planned to enumerate the species of aquatic and soil-water fungi from the vicinity of South Bass Island. Most of the taxa listed were identified after recovery by the usual "baiting" techniques from soil or water samples, although some were identified directly from their natural substrates. The survey was made during June-July, 1959, at the Franz T. Stone Laboratory, Put-in-Bay, Ohio.

The classification followed is that recommended by Sparrow (1943) in which the Phycomycetes are divided into three series—Uniflagellatae, Biflagellatae, and Aplanatae. The present paper does not treat the Aplanatae and the Chytridiales of the Uniflagellatae.

Results and Discussion

The fungi identified during this investigation are listed in table 1. In Sparrow's treatment (1960) the Blastocladales is separated into three families, the Coelomomycetaceae, Catenariaceae, and Blastocladiaceae. The latter family includes the genera *Blastocladiella*, *Blastocladiopsis*, *Allomyces*, and *Blastocladia*. [The genera *Sphaerocladia* and *Clavochytridium*, included by Sparrow in this group (1943), are considered synonyms of *Blastocladiella* in his later work (1960)]. Only members of *Blastocladia*, *Blastocladiella* and *Allomyces* were found during our work. The Monoblastopharidales, with two families (Monoblepharidaceae and Gonapodyaceae), were represented by a sterile *Monoblepharis* and by *Gonapodya prolifera*.

The biflagellate series contains four orders: Saprolegniales, Leptomitales, Lagenidiales, and Peronosporales. In the Saprolegniales only the type family is represented in these collections, no examples of the other two families being found. Within the Saprolegniaceae there are usually 16 genera recognized, eight, or 50% of which are reported from the test area. The 24 species represent more than 25% of the 80 species of Saprolegniaceae reported in the world in the last 70 years. Among the 24 species of water-molds listed is a new species of *Dictyuchus* the description of which will soon be forthcoming. It is distinct from presently known species in having large numbers of eggs or egg-like structure within the hyphae.

Species of *Achlya* were recovered many times, including the nine species listed in table 1. According to the latest revision of the genus (Johnson, 1956) there are 36 valid species, distributed among three subgenera, *Centroachlya*, *Subcentrica*

†Paper 61-7, Department of Botany and Plant Pathology, Michigan State University, and #651, Department of Botany and Plant Pathology, The Ohio State University.

TABLE 1

*Aquatic Phycomycetes collected from South Bass and neighboring islands
in western Lake Erie, June-July, 1969*

Biflagellate	Biflagellatae
Saprolegniales	Saprolegniales (Cont'd)
<i>Achlya polyandra</i>	<i>Aphanomyces euteiches</i>
<i>Achlya dubia</i>	<i>Aphanomyces scaber</i>
<i>Achlya americana</i>	<i>Aphanomyces</i> sp. (sterile)
<i>Achlya proliferoides</i>	Peronosporales
<i>Achlya prolifera</i>	<i>Pythium aphanidermatum</i>
<i>Achlya bisexualis</i>	<i>Pythium debaryanum</i>
<i>Achlya klebsiana</i>	<i>Pythium ultimum</i>
<i>Achlya flagellata</i>	<i>Pythium</i> sp.
<i>Achlya debaryana</i>	<i>Phytophthora undulatum</i>
<i>Achlya</i> sp.	Lagenidiales
<i>Dictyuchus anomalus</i>	<i>Olpidiopsis saprolegniae</i>
<i>Dictyuchus monosporus</i>	<i>Olpidiopsis varians</i>
<i>Dictyuchus pseudodictyon</i>	Leptomitales
and var. with small eggs	<i>Apodachlya brachynema</i>
<i>Dictyuchus missouriensis</i>	Uniflagellatae
<i>Dictyuchus</i> n. sp. (eggs in hyphae)	Blastocladales
<i>Geolegnia inflata</i>	<i>Allomyces arbuscula</i>
<i>Isoachlya</i> sp. (?)	<i>Blastocladiella simplex</i>
<i>Leptolegnia subterranea</i>	<i>Blastocladia ramosa</i>
<i>Protoachlya paradoxa</i>	<i>Blastocladia globosa</i>
<i>Saprolegnia monoica</i>	<i>Blastocladia pringsheimi</i>
<i>Saprolegnia parasitica</i>	Monoblepharidales
<i>Saprolegnia ferax</i>	<i>Gonapodya prolifera</i>
	<i>Monoblepharis</i> sp. (sterile)

TABLE 2

New records of aquatic Phycomycetes in Ohio

Biflagellatae	Biflagellatae (cont'd)
Saprolegniales	Leptomitales
<i>Achlya polyandra</i>	<i>Apodachlya brachynema</i>
<i>Achlya proliferoides</i>	
<i>Achlya prolifera</i>	Peronosporales
<i>Achlya klebsiana</i>	<i>Pythium aphanidermatum</i>
<i>Achlya debaryana</i>	<i>Phytophthora undulatum</i>
<i>Aphanomyces euteiches</i>	
<i>Aphanomyces scaber</i>	Uniflagellatae
<i>Dictyuchus anomalus</i>	Blastocladales
<i>Dictyuchus pseudodictyon</i>	<i>Blastocladiella simplex</i>
<i>Dictyuchus missouriensis</i>	<i>Blastocladia ramosa</i>
<i>Dictyuchus</i> n. sp.	<i>Blastocladia globosa</i>
<i>Leptolegnia subterranea</i>	<i>Blastocladia pringsheimi</i>
<i>Saprolegnia monoica</i>	
<i>Saprolegnia parasitica</i>	Monoblepharidales
<i>Isoachlya</i> sp. (?)	<i>Gonapodya prolifera</i>
<i>Protoachlya paradoxa</i>	<i>Monoblepharis</i> sp. (sterile)
Lagenidiales	
<i>Olpidiopsis varians</i>	

and *Achlya*. Our nine species, eight of which are from the subgenus *Achlya*, represent 25% of the valid species in the genus.

Each of the species listed for the other orders was identified less frequently than were members of the Saprolegniaceae. In the Leptomitales only *Apodachlya brachynema* was identified. Among the members of the Lagenidiales, which contains both aquatic and non-aquatic species, only the parasites *Olpidiopsis*

saprolegniae and *O. varians* were found. In the Pythiaceae of the Peronosporales, *Phytophthora undulatum* (*Pythiomorpha undulata*), *Pythium debaryanum*, *P. aphanidermatum*, and *P. ultimum* were recovered as well as many unidentified *Pythium* species which were not determined during the survey. [See Blackwell, Waterhouse, and Thompson (1941) who present convincing arguments against maintaining *Pythiomorpha* distinct from *Phytophthora*.]

From table 2 it can be seen that 24 species and two genera of aquatic Phycomycetes are reported for the first time from Ohio soil and water.

Summary

During June-July, 1959, 37 species and one variety of aquatic Phycomycetes were identified from soil or water samples, or from plant or animal material collected on South Bass Island or on neighboring islands in western Lake Erie. The fungi found were members of the uniflagellate and biflagellate series of Phycomycetes. Both parasitic and saprophytic organisms are included among the 24 species and one genus reported for the first time from Ohio.

LITERATURE CITED

- Blackwell, E. M., G. M. Waterhouse and M. V. Thompson. 1941. The invalidity of the genus *Pythiomorpha*. Trans. Brit. Mycol. Soc. 25: 148-165.
 Cooke, W. B. and A. F. Bartsch. 1959. Aquatic fungi in water with high waste loads. Sewage and Industrial Wastes 31: 1316-1322.
 ——— and ———. 1960. Aquatic fungi in some Ohio Streams. Ohio J. Sci. 60: 144-148.
 Harvey, J. V. 1952. Relationship of aquatic fungi to water pollution. Sewage and Industrial Wastes 24: 1159-1164.
 Johnson, T. W. 1956. The Genus *Achlya*: Morphology and Taxonomy. Univ. of Michigan Press, Ann Arbor.
 Sparrow, F. K. 1943. Aquatic Phycomycetes, exclusive of the Saprolegniaceae and *Pythium*. Univ. of Michigan Press, Ann Arbor.
 ———. 1960. Aquatic Phycomycetes. Univ. of Michigan Press, Ann Arbor.

Radioactivity Measuring Instruments. M. C. Nokes. Philosophical Library, Inc., New York. 1958. viii+75 pp. \$4.75.

Although the title of this book indicates a rather widespread coverage of the field of radiation measurement, the author has limited himself to a discussion of Geiger-Muller tubes and the electronics associated with that type of radiation detector. About one third of the book is devoted to a description of physical and chemical phenomena within a G-M tube, counting statistics, definitions, and construction techniques. The remainder of the book concerns construction of economical radiation-counting equipment for introductory laboratories. Examples and explanations are given for triggering circuits, power supplies, count-rate circuits, and scalars. Difficulties are bound to arise in the use of this book since the author describes circuits that are designed for use in European laboratories (240 volts, 50 cps) and that utilize British vacuum tubes ("valves"). The British component problem can perhaps be circumvented since some local electronic component suppliers can provide information on suitable domestic replacements. The counting systems described are of both the portable and the laboratory type. Although most of the circuits use vacuum tubes, some transistor circuitry is included. The author's main purpose seems to be to provide sufficient information for the construction of simple but useful counting equipment by persons with "an elementary knowledge of electricity and an ordinary measure of manual dexterity." In this, the book achieves its purpose and instructors in high schools and colleges may find it helpful. It will not be particularly useful, however, to persons with no experience in electricity due to the differences in instrumentation technology and terminology between the United Kingdom and the United States.

WALTER E. CAREY

THE SOILS DEVELOPED ON WISCONSIN AND ILLINOIAN AGE GLACIAL OUTWASH TERRACES ALONG LITTLE BEAVER CREEK AND THE ADJOINING UPPER OHIO VALLEY, COLUMBIANA COUNTY, OHIO

HEBER D. LESSIG

U. S. Soil Conservation Service, Box 248, Lisbon, Ohio

During the progress of the soil survey in Columbiana County, Ohio, two glacial outwash terrace levels were traced from gravelly kame areas in the Wisconsin and Illinoian glacial till plains (White, 1951) along Little Beaver Creek, to the Ohio River (fig. 1). The lower terrace originates in the Wisconsin till plain and is presumed to be Wisconsin glacial outwash. The higher terrace originates in the Illinoian till plain and is presumed to be Illinoian glacial outwash.

The soils developed on these two terrace levels were found to be similar in lithology but to vary in some morphological properties due to difference in age.

Seven well-drained to somewhat excessively drained soil profiles developed from each age of gravelly glacial outwash were sampled and described to determine the soil morphological properties which are common to each respective age of glacial outwash. The properties of soils from Wisconsin outwash and soils from Illinoian outwash, together with detailed profile description of a modal soil of each age, are given.

Physiography of the Region

Columbiana County is in the Allegheny Plateau. Here the plateau consists of knobs at 1360 to 1447 ft, broad gently sloping ridgetops at 1200 to 1320 ft, and benches and lower ridges at 1080- to 1180-ft elevation. (Wellsville, Ohio, W. Va.-Pa.: Lisbon, Ohio: Columbiana, Ohio-Pa; and Salineville, Ohio; quadrangle maps of the U. S. Geological Survey). The physiography and drainage history are described by Stout and Lamborn (1924, p. 9-45). The northern part has been glaciated by the Illinoian and Wisconsin glaciers and is mapped and described by White (1951). The Wisconsin glacial till is classed as Kent till (White, 1953, 1960).

Both the Illinoian and Wisconsin glacial outwash terraces can be traced from gravelly kames, within the respective areas covered by these till sheets, downstream along Little Beaver Creek into the upper Ohio Valley (fig. 1). Within the till sheet boundaries these kames occur as high as the lower parts of the till plains and the terraces are 50 to 100 ft lower in elevation. Beyond each till sheet boundary respective glacial outwashes drop to lower positions in an inner gorge which is the entrenched portion of Little Beaver and upper Ohio valleys. Here the Illinoian terrace remnants range about 100 to 120 ft, and the Wisconsin terrace remnants about 30 to 75 ft above present drainage.

Little Beaver Creek has three tributaries. The North Fork rises in the northeastern part of the county, flows into Pennsylvania and then back into Ohio at Negley. Middle Fork, which is the main tributary, drains the central part of the county. Only the terraces along Middle Fork will be discussed as they are more continuous than those of the other tributaries, but are otherwise similar.

The Middle Fork tributary in the Wisconsin glacial till plain at Leetonia is at 1000-ft elevation. Little Beaver Creek empties into the Ohio River at Smiths Ferry, Pa. at 656 ft. The gradient ranges from 3 ft per mile upstream to 12 ft per mile near its mouth.

Higher pre-Illinoian terraces occur along Little Beaver Creek and the Ohio Valley south of the Illinoian boundary. The higher of these is at 960 to 1020 ft

(Lessig, 1961). A lower pre-Illinoian terrace at 860 to 940 ft occurs about 150 to 200 ft above drainage. It is at 860 ft in the Ohio Valley (Lessig, 1959a) (fig. 1).

Soil Profile Study Methods

The soil profiles are described according to the conventions and terminology outlined in the Soil Survey Manual (Soil Survey Staff, 1951) with the following exceptions. Quantities of pebbles are indicated as estimated percentages by volume and they were identified visually, using a hand lens, where such identifica-

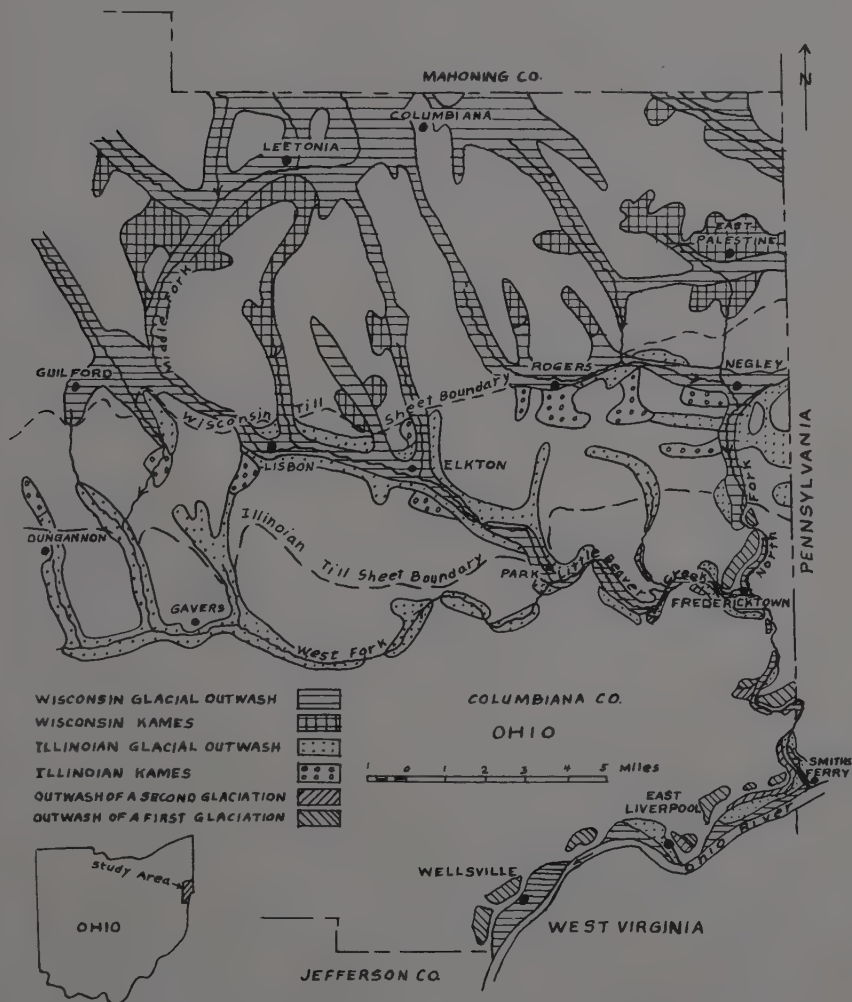


FIGURE 1. Map of glacial outwash terraces in eastern Columbiana County.

tion is given. Coatings and stains on ped faces are described in terms of estimated thickness and texture, and in terms of color according to Munsell notations. Some horizon designations and interpretations are made according to recent definition in "Soil Classification, A Comprehensive System, 7th Approximation" (Soil Survey Staff, 1960). Determinations of pH, made colorimetrically in the field, are given in the profile descriptions, but those reported in table 1, together with data on particle size distribution, are laboratory determinations. Colors and consistence are given for moist conditions. Mechanical analyses were made in the laboratories of The Ohio Agricultural Experiment Station, according to procedure described by Kilmer and Alexander (1949, p. 15-24). Chemical analyses were made in the laboratories of The Ohio Agricultural Experiment Station as follows: exchange acidity was determined by methods of Mehlich (1948). Bases were extracted with normal neutral NH_4Ac (Bray and Willhite, 1929). Potassium was determined by use of Bechman Model DU flame photometer. Calcium and magnesium were determined by EDTA (ethylenediamine-tetraacetate) photometric titration (Shapiro et al., 1956). Exchange acidity, calcium, magnesium, and potassium were added to obtain the sum of exchangeable cations.

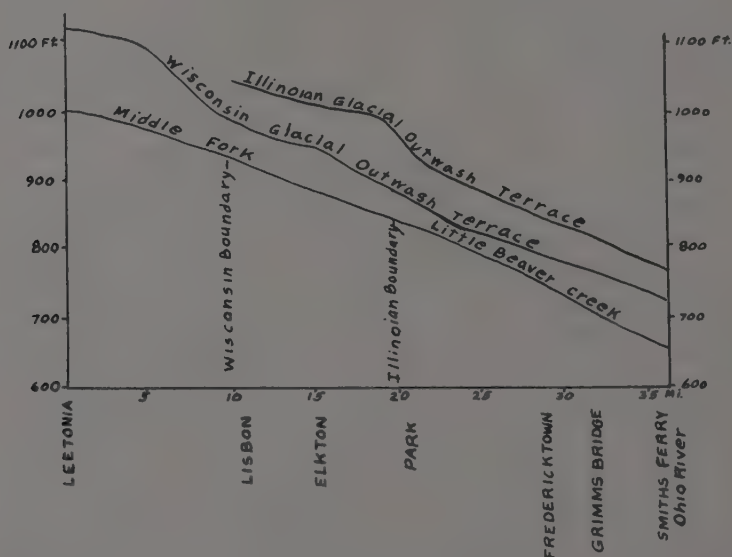


FIGURE 2. Diagram of gradients of Wisconsin and Illinoian-age terraces along Middle Fork and Little Beaver Creek.

Description of the Wisconsin Glacial Outwash Terrace

The Wisconsin glacial outwash terrace is nearly continuous from kames along Little Beaver tributaries, in the Wisconsin glacial till plain to the mouth of Little Beaver Creek at Smiths Ferry (fig. 1). The highest areas of the terrace are at 1180 ft north of Guilford, in the headwaters of West Fork; 1080 ft in the far northeastern part of the county along North Fork; and 1120 ft near Leetonia along Middle Fork. Downstream, the terrace along Middle Fork descends

sharply to 960 ft at the Wisconsin till sheet boundary near Lisbon. It descends rapidly again to 860 ft near the Illinoian till sheet boundary at Park. Downstream it grades to 780 ft at Fredericktown and to 740 ft near the mouth of Little Beaver Creek (fig. 2).

The terrace in the Ohio Valley occurs as remnants on either side of the river. It is at 700- to 720-ft elevation in the east part of East Liverpool and at Wellsville, about 50 ft above river level.

Generally beyond the Wisconsin boundary, the terrace is 40 to 60 ft below the Illinoian terrace. Along Little Beaver Creek it is narrow, ranging from a few hundred to a thousand feet wide, but the terrace in the Ohio Valley is about a half mile wide in some places.

Soil Profiles on the Wisconsin Glacial Outwash Terrace

Soils on the Wisconsin terrace are formed in sandy and gravelly and silty glacial outwash. They are mostly somewhat excessively and well-drained, with silt loam to gravelly loam surface soils and gravelly loam to gravelly sandy loam subsoils. The substratums range from gravelly sandy loam to loamy sand. The solums are moderately deep and leached of carbonates to depths of 6 to 7 ft where the parent materials contain about 5 to 10 percent CaCO_3 , or equivalent, material.

A modal profile was sampled and described at a point 3 miles east of Lisbon along State Route No. 154, about 400 ft northeast of a junction with a township road in the NE $\frac{1}{4}$ Sec. 20, Elkrum twp. The site has a 4 percent convex slope and is at 950-ft elevation. Middle Fork, Little Beaver Creek, just below the site, is at 900 ft and the upland is at 1160 ft.

Profile 1.—Description of a somewhat excessively drained soil profile developed from Wisconsin-age gravelly glacial outwash.

Depth and Horizon	Profile Description
0-8 in. A _p	Dark brown (10YR 3/4) gravelly loam; weak very fine angular to subangular blocky structure; friable; pebbles 25%; strongly acid, pH 5.3; boundary clear, smooth.
8-18 in. B ₁	Brown (7.5YR 4/4) gravelly sandy loam; weak medium subangular blocky structure; very friable; pebbles 60%; medium acid, pH 5.6; boundary clear, wavy.
18-45 in. B ₂₁	Dark brown (7.5YR 4/4) gravelly sandy clay loam to sandy loam; weak medium angular blocky structure; very friable; clay coated pebbles 75%; medium acid, pH 5.8; boundary gradual.
45-60 in. C ₁	Dark brown (7.5YR 4/4) gravelly sandy loam; massive; very friable to noncoherent; pebbles 75%, some coated by clay; slightly acid to neutral, pH 6.4 to 7.0; boundary clear, smooth.
60-120 in. C ₂	Brown (10YR 4/3) sand and gravel; massive; non-coherent; pebbles 60%; mildly alkaline, pH 7.4; weak effervescence at 70 in., CaCO_3 equivalent, 6.9% (lab.); sand and gravel more than 20 ft deep; pebble count at 120 in., 1055 pieces:—41% sandstone, 17% limestone, 12% quartzite, 9% chert, 9% granite, 8% concretions, 4% quartz.

The morphology of this soil shows a textural B horizon, which is evidenced by the clay content of the B₂ horizon at 18 to 45 in. (table 1). However, color and structural development in the B horizons are weak. The profile has a friable consistence. Clay is found as coatings on pebbles and bridges between sand grains to a 53-in. depth. However the clay content of 21% at 23 to 28 in. (table 1) is unusually high for Wisconsin-age gravelly soils. This soil is strongly acid above 45 in. and is leached of carbonates to a 70-in. depth. Pebbles of limestone are not found above 70 in. The pebbles of granite in the solum do not have strongly

weathered rinds. The unweathered outwash at the 120-in. depth contains a high percentage of foreign rocks. In the B horizon, the percentage of base saturation ranges from 19 to 58 percent and the ratio of calcium to magnesium ranges from 1.5 to 6.1 (table 1). The soil profile described is tentatively classed in the Chili series in the Columbiana County soil survey, a Gray-Brown Podsolc soil.

TABLE 1
Laboratory data for Profiles 1 and 2

Depth in inches	Hori- zon	Particle size distribution (in mm) (percent)					pH	Chemical				Base satur- ation in percent	Ratio of Ca/Mg
		Sand 2-0.05 mm	Silt 0.05-0.002 mm	Total Clay >.002 mm	Fine Clay >.0002 mm	Exchangeable Cations in mEq./100 gm.							
						H		Ca	Mg	K			
Profile 1—Soil formed from Wisconsin-age gravelly glacial outwash													
0-8	A _p	40	45	15	4	4.9	9.8	1.6	1.5	0.3	26	1.1	
8-12	B ₁	62	25	13	3	4.8	7.3	1.3	0.2	0.2	19	6.1	
12-18	B ₁	74	15	11	4	5.0	6.6	2.0	0.6	0.1	26	3.3	
18-23	B ₂	66	16	18	9	5.1	7.1	3.9	2.7	0.2	49	1.5	
23-28	B ₂	67	12	21	11	5.1	7.5	4.3	2.7	0.3	49	1.6	
28-37	B ₂	72	9	19	11	5.1	7.5	3.9	2.1	0.3	46	1.9	
37-45	B ₂	75	6	19	13	5.4	6.0	5.7	2.4	0.3	58	2.4	
45-53	C ₁	79	8	13	6	6.0	3.9	3.1	2.4	0.2	59	1.3	
53-60	C ₁	88	5	7	3	7.3							
65-70	C ₂	95	2	3	2	7.6							
Profile 2—Soil formed from Illinoian-age gravelly glacial outwash													
0-1	A ₁	52	40	8	2	5.2	22.3	6.3	3.9	0.6	3	1.6	
1-9	A ₂	31	52	17	3	4.2	8.6	0.6	0.1	0.2	10	6.0	
9-11	B ₁	37	40	23	7	4.2	10.8	0.3	0.1	0.2	5	3.0	
11-17	B ₂₁	50	19	31	11	4.2	14.8	0.3	0.7	0.3	8	0.4	
17-28	B ₂₁	50	17	33	16	4.4	14.4	2.1	1.1	0.4	20	1.9	
28-39	B ₂₂	63	14	23	9	4.7	10.4	2.1	1.2	0.4	26	1.7	
39-72	B ₃₁	72	14	14	6	4.7	8.9	1.6	1.0	0.2	24	1.6	
72-99	B ₃₂	75	11	14	5	4.9	7.9	1.1	2.0	0.1	29	0.5	
99-135	C ₁	83	9	8	2	4.8	9.4	1.0	2.1	0.1	25	0.5	
135-171	C ₂	75	11	14	5	6.1	3.7	3.7	1.5	0.1	59	2.5	
171-267	C ₂	77	9	14	5	6.0	3.4	3.3	2.3	0.1	61	1.5	
267-300	C ₂	75	11	14	6	7.7							

Six other soils studied and sampled, which are formed in Wisconsin gravelly outwash, have brown to dark brown (10YR hue) A horizons; dark brown (7.5YR hue) textural B horizons with weak structure. The average ratio of percentage clay in B horizons to clay in A horizons of these other profiles is 1.3 (table 3). Only one profile sampled has such a ratio of less than 1.2. These soils are gritty throughout and lack fragipans. Depths to carbonates vary from 5 to 10 ft, according to the amount of pebbles of limestone in the outwash. Sandy horizons tend to be acid even though they are unweathered. Horizons containing a large amount of gravel tend to be more alkaline. Figure 3 is compiled by averaging the pH value at various depths of 10 soils formed in Wisconsin and 14 soils formed in Illinoian gravelly glacial outwash. The Wisconsin soils have an average pH ranging from 5.0 to 5.4 at 10 to 45 in. They are neutral in reaction at the 70-in. depth. Other common morphological properties are given in tables 2 and 3 and are compared below in the section on soil profiles of the Illinoian glacial outwash terrace.

Description of the Illinoian Glacial Outwash Terrace

The Illinoian glacial outwash terrace is continuous along Middle Fork and other tributaries from gravelly kames in the Illinoian glacial till plain to the glacial boundary. Along Middle Fork the general terrace level is at 980- to 1040-ft elevation. It descends sharply to 920 ft into the gorge of Little Beaver Creek at the Illinoian boundary at Park. Downstream the remnants are at 840 ft at Fredericktown and 770 to 740 ft at the mouth of Little Beaver Creek and along the Ohio River at East Liverpool (fig. 2). Generally, it is 40 to 80 ft higher than the Wisconsin terrace and 90 to 120 ft above drainage. Beyond the glacial boundary along Little Beaver Creek it is only a few hundred feet wide but in the Ohio Valley it is a half mile wide.

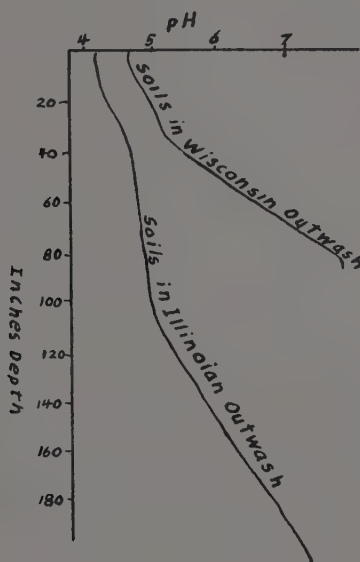


FIGURE 3. Curves showing average pH at various depths of 10 soils formed from Wisconsin-age and 14 soils formed from Illinoian-age glacial outwash in Columbiana County, Ohio.

Soil Profiles on the Illinoian Glacial Outwash Terrace

Soils on the Illinoian terrace are formed in silty to gravelly and sandy glacial outwash which is similar to that of the Wisconsin terrace. However, the upper solums are usually more silty and moderately well-drained soils are more common on the Illinoian terrace, but well to somewhat excessively drained soils predominate. The solums are usually deep and leached to depths of 17 to 20 ft, where the parent materials contain about 5 percent of CaCO_3 , or equivalent materials.

A modal profile was sampled and described on a kame in the center of the $\text{SW}\frac{1}{4}$ of $\text{SE}\frac{1}{4}$ of $\text{NE}\frac{1}{4}$ Sec. 20, Center Twp. The sample site is in a gently sloping forested area at the crest of an 18 percent slope, at a 1200-ft elevation. The area nearby is presently being strip mined for coal. West Fork Little Beaver Creek is just below at a 1060-ft elevation.

Profile 2.—Description of somewhat excessively drained soil profile developed from Illinoian-age gravelly glacial outwash (described and sampled by W. F. Hale and H. D. Lessig)

Depth and Horizon	Profile Description
0-1 in. A ₁	Black (10YR 2/1) gravelly sandy loam; weak very fine granular structure; friable; pebbles 20%; strongly acid, pH 5.2; boundary abrupt, wavy.
1-9 in. A ₂	Yellowish brown (10YR 5/4) gravelly silt loam; weak very fine granular structure; friable; pebbles 20%; very strongly acid, pH 4.8; boundary abrupt, smooth.
9-11 in. B ₁	Dark yellowish brown (10YR 4/4) gravelly loam; weak fine angular blocky structure; brown (7.5YR 4/4) degraded clay ped faces; friable; pebbles 30%; very strongly acid, pH 4.6; boundary clear, wavy.
11-28 in. B ₂₁	Dark brown (7.5YR 4/4) gravelly clay loam to sandy clay loam with common coarse black Mn stains; moderate medium angular to subangular blocky structure; thin reddish brown (5YR 4/4) clay coatings on all pebbles; firm in position but friable when disturbed; pebbles 50%; strongly acid, pH 4.6; boundary gradual.
28-39 in. B ₂₂	Brown (7.5YR 4/4) gravelly sandy clay loam; weak medium and fine angular blocky structure; firm in position but friable when disturbed; pebbles 60% with thin reddish brown (5YR 4/4) clay coatings on pebbles; strongly acid, pH 5.2; boundary clear, wavy.
39-72 in. B ₃₁	Brown (7.5YR 4/4) gravelly sandy loam; very weak medium and fine angular blocky structure; friable; pebbles 60% with thin clay coatings on pebbles, in pores, and bridging sand grains; strongly acid, pH 5.2; boundary abrupt, smooth.
72-99 in. B ₃₂	Dark yellowish brown (10YR 4/4) gravelly sandy loam; weak coarse angular blocky structure; friable; pebbles 30% with thin clay flows on pebbles and bridging sand grains; strongly acid, pH 5.2; boundary abrupt smooth.
99-135 in. C ₁	Brown (10YR 5/3) gravelly loamy sand; massive; noncoherent; pebbles 40%; very strongly acid, pH 5.0.
135-267 in. C ₂	Brown (10YR 4/3) gravelly sandy loam; massive; noncoherent; pebbles 70%; slightly acid, pH 6.4.
267-300 in. C ₃	Dark grayish brown (10YR 4/2) gravelly sandy loam; strong effervescence, pH 7.3; CaCO ₃ equivalent 2.4% (lab.); pebble count 300-in. depth, 311 pieces:—sandstone 40%, siltstone 11%, limestone 15%, quartzite and quartz 9%, granite 4%, concretions 14%, chert 6%, gneiss and schist 1%.

The morphological properties of this profile are a textural B horizon at 9 to 39 in. (table 1), and a structural and color B horizon at 11 to 99 in. The soil profile at 11 to 39 in. is firm but friable when removed. It is extremely to very strongly acid at the 135-in. depth (table 1), and is leached of carbonates to 267 in. The pebble composition at 300 in. is comparable to that found in the Wisconsin outwash at 120 in. In the B horizon the percentage of base saturation ranges from 5 to 29 percent. The ratio of calcium to magnesium ranges from .4 to 3.0 (table 1). This profile is tentatively classed in the Negley series in the Columbiana County Soil Survey.

Six other soils studied which are formed in Illinoian-age gravelly outwash have brown to dark brown (10YR hue) silt loam surface soils; dark yellowish brown loam to silt loam upper subsoils; and dark brown (7.5YR hue) gravelly sandy clay loam lower subsoils. These subsoils have a moderate grade of structure

The substratums are brown gravelly sandy loam. The average pH value at various depths of 14 soils formed in Illinoian gravelly outwash ranges from 4.2 to 4.6 at 10- to 45-in. depths. They are neutral in reaction at 190-in. average depth (fig. 3). These solums are less gritty than those of the Wisconsin age outwash and usually have higher amounts of silt in the upper solums. Pebbles of granite in the solums have strongly weathered rinds but are not strongly weathered in their interiors.

Generally soils formed in glacial outwash with a lower percentage of limestone pebbles are more deeply leached and those with a higher percentage of concretions (kidney iron ore) are more reddish. The lithology of gravel in local glacial outwash varies within short distances.

TABLE 2
Average percentages of clay found at various depths in soils formed from Wisconsin-age and Illinoian-age gravelly glacial outwash

Inches in depth	0-8	8-12	12-22	22-30	30-47	47-62	62-92	92-240
Seven Wisconsin-age soils	14	15	16	15	14	11	8	
Seven Illinoian-age soils	17	22	25	23	18	17	13	9

TABLE 3
Average morphological properties of soils developed from Wisconsin-age and Illinoian-age gravelly glacial outwash

	Laboratory pH of B ₂ horizon	Depth to carbonates	Depth great decrease in clay content	Greatest depth in soil at which clay coats sand and gravel	Ratio of % clay in B to % clay in A horizon	Depth to which 7.5 YR hue color occurs
Seven Wisconsin-age soils	5.2	84 in.	43 in.	59 in.	1.3	59 in.
Seven Illinoian-age soils	4.6	210 in.	61 in.	100 in.	1.6	90 in.

In table 3 the data show the Illinoian-age soils are 0.6 pH (determined in the laboratory) more strongly acid; 126 in. more deeply leached; have 18-in. thicker zones of increased clay; have clay coatings and bridges on sand and gravel to 41-in. greater depth; and have 4 to 9 percent more clay in the B horizon (table 2) than the Wisconsin-age soils. The average ratio of percentage clay in the B horizon to percentage clay in the A horizon is 1.6 in the Illinoian-age soils as compared to 1.3 in the Wisconsin-age soils. The average percentage base saturation of the B horizon of the Illinoian soil (Profile 2) is 18 as compared to 41 percent in that of the Wisconsin soil (Profile 1). The average ratio of calcium to magnesium is 1.5 in the Illinoian B horizon as compared to 2.8 in the Wisconsin B horizon.

The local soils formed in Wisconsin-age and Illinoian-age glacial tills have similar differences, but they have strong fragipans and higher clay content than the soils formed in outwash.

Discussion

The soil developed from Wisconsin-age gravelly glacial outwash (Profile 1) is not so deep as the soil developed from Illinoian-age gravelly glacial outwash (Profile 2). Profile 1 has significantly smaller amounts of clay, less structure, is more friable, and is less acid than Profile 2. However, these two profiles are developed in parent materials with similar lithology. They have similar colors in the various soil horizons except that comparable horizons are thicker in Profile 2.

These variances are shown in tables 2 and 3, where average morphological properties of 7 soils developed in Wisconsin-age gravelly glacial outwash are compared with 7 soils developed in Illinoian-age gravelly glacial outwash. These differences in averages, discussed under Profile 2, show the same greater degree

of soil formation in Illinoian-age soils than in the Wisconsin-age soils. The thickness of the B₂ horizons, as identified in the field, and the depth in the solums to which 7.5YR hue, dark brown colors are found, is less in the Wisconsin-age soils. The morphological differences between the Wisconsin-age and Illinoian-age soils apparently are a matter of degree rather than quality. The older Illinoian soils have developed over a longer period of time, encompassing the Sangamon interglacial stage, the Wisconsin glacial stage and post-Wisconsin time. They have a greater amount of soil formation. The Illinoian-age soil has a lower base status than the Wisconsin-age soil. It also has a lower calcium content in proportion to the amount of magnesium. These are evidence of a greater amount of leaching due to a longer period of soil formation.

I found no evidence that variations in post-Illinoian climates produced a different kind of soil formation in Profile 2 from that in Profile 1. However, Profile 2 (Illinoian) has less than 35 percent base saturation in the B horizon and, thus, fits Red-Yellow Podsolc soils or Ultisols (Soil Survey Staff, 1960). It lacks the yellowish-red colors which is found in soils formed in pre-Illinoian outwash.

Other soils in the region, which I believe to be formed from pre-Illinoian glacial outwash, have higher chromas in the 5YR hue colors, higher percentages of clay formed in the B horizons, and are leached to greater than 30-ft depths. Some have plinthite. The pebbles of granite in these solums are entirely decomposed or lacking. These soils are interpreted to be Red-Yellow Podsolc soils (Lessig, 1959b, 1961).

Conclusion

The soils developed from Wisconsin-age gravelly glacial outwash along Little Beaver Creek and the upper Ohio Valley have similar profiles to soils developed from Illinoian-age gravelly glacial outwash, but are not as strongly formed and as deeply weathered. The Illinoian-age soils have thicker B horizons, more clay formed, are more acid, more deeply leached, have a lower base status and a lower calcium-magnesium ratio than the Wisconsin-age soils. The Illinoian-age glacial outwash terrace is 40 to 60 ft higher than the Wisconsin-age glacial outwash terrace along Little Beaver Creek. In the upper Ohio Valley the Illinoian terrace is at 740 to 770 ft and the Wisconsin terrace is at 700- to 720-ft elevation. Both these terrace levels are lower and their soils are less deeply formed than those of older and higher glacial outwashes at about 860- and 960-ft elevations in the upper Ohio Valley (fig. 1) described in my earlier reports.

REFERENCES

- Bray, R. H. and F. M. Willhite. 1929. Determination of total replaceable bases in soils. *Industr. Engng. Chem. Analyt. Ed.* 1: 144.
- Kilmer, V. J. and L. T. Alexander. 1949. Methods of making mechanical analyses of soils. *Soil Sci.* 68: 15-24.
- Lessig, H. D. 1959a. Buried soils of Globe Hill, upper Ohio Valley. *Ohio J. Sci.* 59: 48-54.
- . 1959b. The supermarket terrace, near East Liverpool, Ohio. *Ohio J. Sci.* 59: 332-338.
- . 1961. Soils of the high terrace remnants in the upper Ohio Valley. *Ohio J. Sci.* 61: 25-37.
- Mehlich, A. 1948. Determination of cation and anion exchange properties of soils. *Soil Sci.* 66: 429-445.
- Shapiro, L. and W. W. Brannock. 1956. Rapid analyses of silicate rocks. *U. S. Geol. Surv. Bull.* 1036C, pp. 38-42.
- Soil Survey Staff. 1951. *Soil Survey Manual*. U. S. Dept. Agric. Handbk. 18, pp. 265-250.
- . 1960. *Soil Classification, A Comprehensive System, 7th Approximation*. U. S. Govt. Printing Off., pp. 24-30.
- Stout, W. and R. E. Lamborn. 1924. *Geology of Columbiana County*. Geol. Surv. Ohio. 4th ser. Bull. 28, pp. 9-45.
- White, G. W. 1951. Illinoian and Wisconsin drift in the southern part of the Grand River lobe in eastern Ohio. *Bull. Geol. Soc. Am.* 62: 967-977.
- . 1953. Geology and water-bearing characteristics of the unconsolidated deposits of Cuyahoga County, in Winslow, J. D., White, G. W., and Webber, E. E., Ohio Div. of Water Bull. 26, pl. 26.
- . 1960. Classification of Wisconsin glacial deposits in northeastern Ohio. *U. S. Geol. Surv. Bull.* 1121-A, pp. 5-6.

MAJOR PREGLACIAL, NEBRASKAN AND KANSAN GLACIAL DRAINAGES IN OHIO, INDIANA, AND ILLINOIS

GEORGE N. COFFEY

352 North Bever Street, Wooster, Ohio

The drainage as it exists today in the area under consideration has been brought about through various agencies and processes which worked on the underlying rock material over long intervals of geological time. The character, elevation, and slope of the surface rock formations, and especially the advance southward from Canada of the different glaciations over most of the northern part of the United States, have been the most important factors in determining the drainage.

Underlying Rock Formations

The different rock formations as they appear at the surface in the three states herein considered are outlined in figure 1 and are taken from state geological maps. They are known as the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian and Permian systems.

The material composing the different geological systems was originally deposited in shallow seas in the form of sand, silt, clay, and calcareous ooze and later was consolidated into sandstones, shales, and limestones; and during the formation of the Appalachian Mountains, it was uplifted and tilted so that today, in most of the area under consideration, the formations are no longer horizontal, but in certain areas they have been arched upward into anticlines. This increased the erosion, so that in some areas the younger formations have been removed and the older ones, generally more easily eroded, now constitute the surface at practically the same elevations, or even a higher one than some sections of the younger formations.

Such an arch, including the Ordovician, Silurian, and Devonian formations, sometimes referred to as the Cincinnati anticline, extends northward from Kentucky through southwestern Ohio and southeastern Indiana and divides, one section turning northeastward through Lake Erie and also northwestward around Lake Huron and the other section turning northwestward through northern Indiana and Illinois and then northward around Lake Michigan to unite with the Lake Huron section, thus surrounding the younger geological formations in the southern Michigan peninsula.

A fault extends northwestward across northern Illinois. North of this fault line the older geological formations, principally Ordovician and Silurian, constitute the bedrock surface while south the younger formations, principally Mississippian, form the surface.

A narrow band, known as the LaSalle anticlinal belt, along which the rock formations have been warped upward, extends southeastward from Ogle County in northern Illinois to Wabash County, but the older geological formations reach the rock surface in only a few small areas along this belt.

The elevations of the different formations gradually decrease at approximately right angles to the direction of the anticlinal axes and the rate of erosion also decreases, so that the younger formations (fig. 1) successively constitute the surface, except in some areas where streams have formed deep, and in some sections broad, valleys, in which the older formations form the bedrock surface. The younger formations constitute the bedrock surface in practically all the eastern half of Ohio, except the extreme northern part and also the southwestern part of Indiana and practically all of Illinois, except the northern part.

Of the older formations the Devonian was probably the most easily eroded

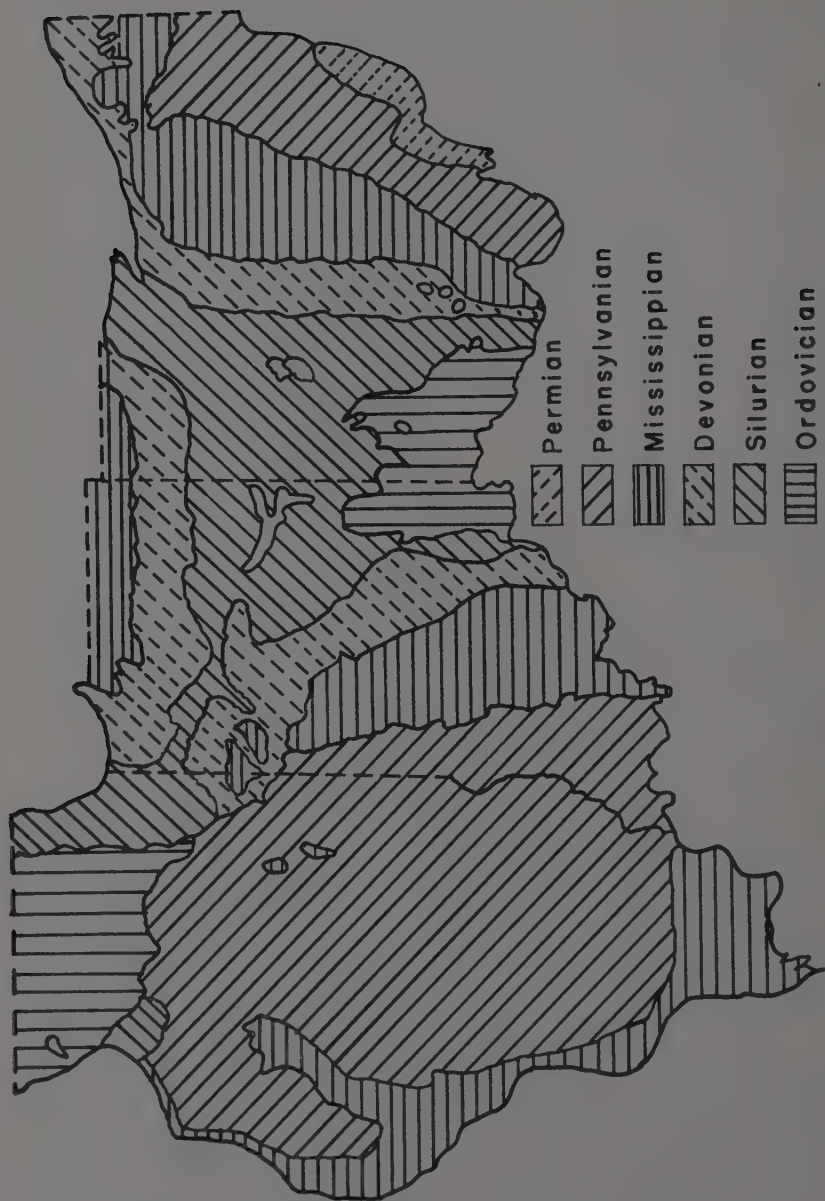


FIGURE 1. Geological map of Ohio, Indiana, and Illinois.

and this resulted in the formation of the broad Scioto Valley, which extends northward from the Ohio River through central Ohio to the Lake Erie plains. In Indiana a rather similar broad valley, known as the Scottsborough lowland, extends northwestward from the Ohio River near New Albany, through this lowland, which is likewise underlain by the Devonian formation and in northwestern Indiana almost connects with another section, which extends eastward from Lake Michigan across northern Indiana and northwestern Ohio to Lake Erie. In Illinois the Devonian formation was evidently removed in the area north of the fault line except a small area near the Indiana line.

Elevation of Bedrock Surface

The present elevation of the bedrock surface furnishes some of the most important evidence in considering the location of the preglacial drainage and the changes that were brought about by the advance of the different glaciations. Contour maps of the bedrock surface have been made covering most of the three states considered, except the southeastern part of Ohio; but the contour intervals are not the same, making it somewhat difficult to adjust the contours along the boundary between the states. On maps for Ohio by Stout (1943) and Cummings (1959), the contour intervals are 100 ft; for Indiana (Wayne, 1956), 250 ft; and for Illinois (Horberg, 1950), 50 ft. A map, compiled from these state maps, is shown in figure 2. On it are roughly indicated the 1000-ft contours in Ohio and a few small areas in Indiana, the 750-ft contours in Indiana and the 600- and 700-ft contours in Illinois. The areas surrounded by the contours have an elevation higher than that indicated on the contours, and those not so included usually have a lower elevation.

The contours on the bedrock surface maps indicate that the highest elevations are in Ohio, where the divides and many small areas in the north and east central and northeastern parts of the state are above 1200 ft, with the highest elevation, near Bellefontaine in Logan County, over 1300 ft. The elevation in northwestern Ohio, along Lake Erie and the larger valleys, is less than 800 ft. In the lower Maumee and Sandusky river valleys and extending as a narrow strip eastward along Lake Erie and also along the Scioto, old Mahomet, Miami and Ohio Rivers and some other streams, the bedrock surface elevation is below 600 ft or near the level of Lake Erie, which is 573 ft.

There are only a few small areas in Indiana where the bedrock surface is above 1,000 ft. The largest one extends north from the Ohio River west of New Albany and is a part of the Norman upland. Three others are in the east central section and one is in the southeastern part. Most of the southeastern part of the state, except the Scottsborough lowland, which extends northward from the Ohio River at New Albany, is above 750 ft, while the remainder is below 750 ft. The southwestern part, the old Mahomet Valley, a small area in the northeast part and also one bordering Lake Michigan are below 500 ft.

The section of Ohio and Indiana with higher bedrock elevations, often referred to as an extension of the Appalachian Plateau, or the Lexington Peneplain, extends northward in eastern Ohio almost to Lake Erie and from there its northward boundary is southwestward through central Crawford County, northern Logan and Drake Counties and continues southwestward and includes most of southeastern Indiana, but is intersected by the broad Scioto and Miami valleys in Ohio and the Scottsburg lowland in Indiana. As the bedrock elevation north of this plateau decreases northward toward Lake Erie and Lake Michigan, it would seem to indicate that the preglacial drainage in Ohio and most of Indiana, except the southwest part, was northward into the lake basins.

Most of the northern and western parts of Illinois are above 600 ft and a considerable proportion are above 700 ft. In the extreme northwestern part of the state much of the area is above 800 or 900 ft and a few small areas are above



FIGURE 2. Contour map showing elevations of bedrock surfaces in Ohio (1000 ft), Indiana (750 ft), and Illinois (600 and 700 ft).

1,000 ft. Along the Indiana line in east central Illinois and extending south and then west across the south central part of the state to the Mississippi River, almost all the elevation is above 600 ft, except where it is intersected by the deep narrow valley of the Illinois River and in a few places by other small valleys. It may be possible that in preglacial time the elevation of the bedrock surface in practically all of Illinois north of this divide was more than 600 ft. In most of the central and southern part and a strip along Lake Michigan, the bedrock surface is less than 600 ft. Along the old Mahomet and present Illinois River valleys and their principal tributaries, and also in most of southern Illinois and in small areas along Lake Michigan, the bedrock surface is less than 500 ft; and along the center of the main valleys, including the old Mahomet River, it is less than 300 ft.

Preglacial Drainage

The first preglacial drainage systems were determined by the shapes of the newly emerged lands. But as the elevation and slope of the surface became greater in some sections than in others and rocks of various resistance were exposed, new systems with some large streams and broad valleys were developed; but the advance of the different glaciations, especially the earlier ones, brought about so many reversals and other changes in the streams and the formations of new channels, or the deepening of old ones, that it is often difficult, or even impossible, especially in Illinois, to determine the location of the preglacial divides, valleys, and streams.

It has generally been recognized that there was no preglacial Ohio River. There is some positive evidence (Coffey, 1958) that in preglacial time all drainage in Ohio was northward into the Lake Erie basin and also evidence that much of that in Indiana and possibly in Illinois was northward into the Lake Michigan basin. A map of the probable preglacial divides and drainage, based upon an interpretation of the available data, is shown in figure 3. The preglacial drainage in Ohio, indicated on this map, is practically the same as that on the map in my 1958 article (*ibid.*) with a few changes having been made to accord with the later map by Cummings (1959).

Teays and Mahomet Rivers

Probably the most important question regarding the early drainage in Ohio, Indiana, and Illinois is whether the old Teays River in preglacial time flowed northward from Chillicothe through the present broad Scioto Valley into the Lake Erie basin, or whether it turned northwestward in Pickaway County and continued along the old comparatively narrow, abandoned Mahomet Valley across the divide between the present Scioto and Miami Valleys and continued into and then westward across Indiana and southwestward through Illinois to the Mississippi River. If the former represents the true preglacial drainage of the Teays River, then the Mahomet River must have been formed by the blocking of the northward Teays drainage by the advance of an early glaciation, probably the Nebraskan.

The present Scioto Valley, and northward to Lake Erie, is underlain by the Devonian geological formation, which evidently was easily eroded. It would certainly seem more natural for the old Teays River to have extended northward to Lake Erie and to have been primarily responsible for the formation of the broad Scioto Valley rather than to have turned northwestward on what, if true, would have been the divide between the Great Lakes and the Gulf drainage. No other explanation of the origin of this broad upper Scioto Valley, so far as I know, has been offered. Positive evidence on this question is shown on a bedrock surface map by Stout (1943) and on one by Cummins (1959). Leverett (1897: 21) suggested the former as one of the possible courses.

The elevation of the bedrock surface in the broad upper Scioto Valley, as

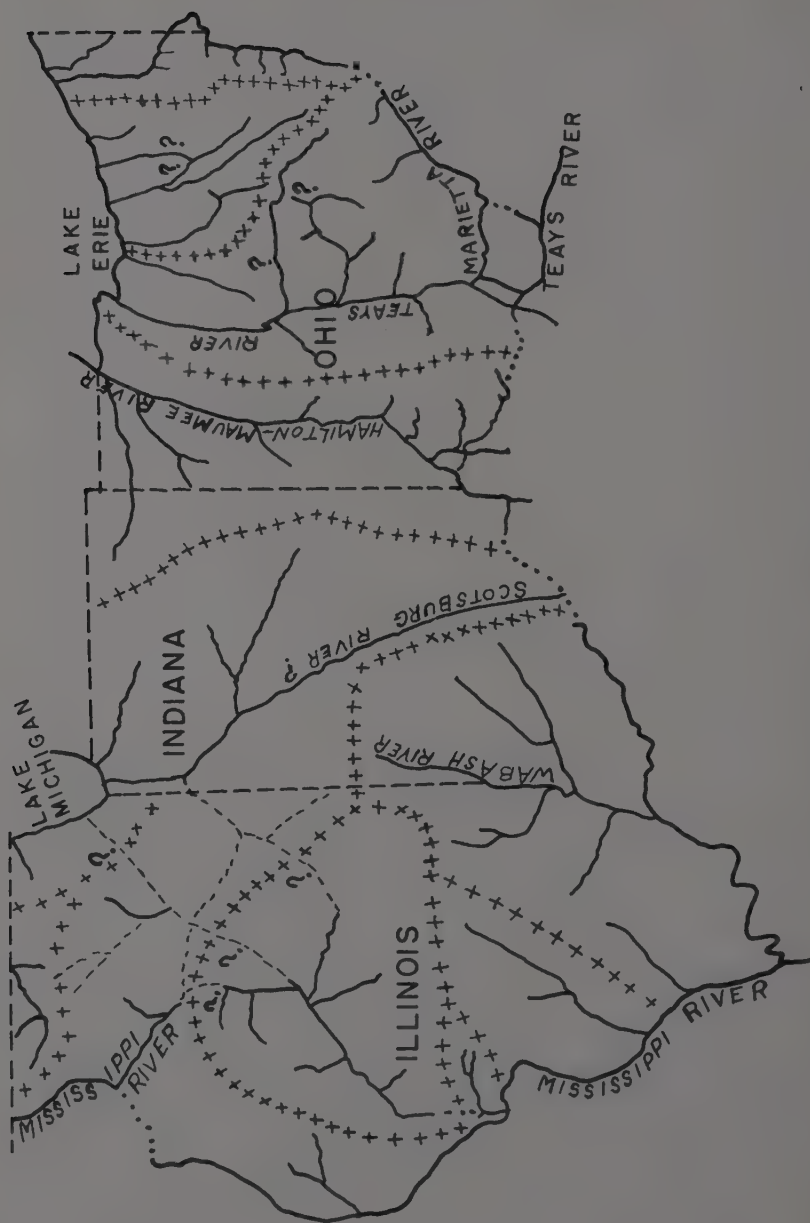


FIGURE 3. Preglacial divides and streams.

indicated on these maps, for a width of more than 30 miles, is less than 1,000 ft and some sections is less than 900 ft, while the hills on each side rise rather abruptly to more than 1,200 ft and in some small areas to more than 1,300 ft. From Logan County, which has the highest present surface elevation of 1,533 ft in the three states included herein, southward along the divide between the Scioto and Miami Valleys almost to the Ohio River, the bedrock elevation is, for practically the entire distance, above 1,000 ft and in some places is more than 1,100 ft, except in Champaign, Clark and Madison Counties where the deep, narrow, abandoned channel of the old Mahomet-Teays River, having a bedrock elevation of less than 600 ft, extends northwestward across the divide and continues across the old Hamilton River valley, where the surface elevation is less than 800 or 900 ft, into Indiana and Illinois, thus forming the old Mahomet River.

The old Mahomet-Teays River continued until the Kansan glaciation advanced southward much beyond the old Mahomet in all three states. This resulted in the deposition of glacial material in all of the old valley and the elimination of this stream, and many other preglacial streams, throughout practically its entire length.

This and other data on the bedrock surface maps furnish positive evidence that the preglacial Teays River, and also the old Hamilton-Maumee River, flowed northward into the Lake Erie basin and that the abandoned channel of the old Mahomet River through Ohio, Indiana and Illinois must have resulted from the later blocking of the northward flow of the old Teays and Hamilton Rivers as well as much of the preglacial drainage in Indiana and Illinois by the advance of an early glaciation, probably the Nebraskan. This advance caused the old Teays River to break over the divide on the west and, during the thousands of years before the coming of the Kansan glaciation, cut out a deep and in some places narrow valley, making it interglacial rather than preglacial in origin. This offers the only logical explanation for the origin of the present broad upper Scioto Valley, as well as for other deep valleys, which is difficult or even impossible to explain otherwise.

Ohio Preglacial Drainage

Geologists generally agree that there was no preglacial Ohio River and that there was a divide in Monroe County from which the drainage flowed northward, joined the old Pittsburgh drainage and continued northward through the present Mahoning and Grand River valleys into the Lake Erie Basin. From this same divide the drainage was southwestward along the present Ohio River valley to about Gallipolis, where it turned westward and northwestward and joined the old Teays River in the present Scioto Valley near Waverly.

The divide in Monroe County extended northward at an elevation of more than 1,200 ft and in Belmont County divided, one section extending northward to near Lake Erie and the other one extending northwestward across the present Tuscarawas Valley near Port Washington and continuing westward through southern Holmes, Ashland, and Richland Counties to eastern Morrow County. The area north of this divide and west of the other one extending north from Belmont County to Lake Erie has been dissected into so many deep connected valleys by the advance of the glaciers, that it is impossible to determine definitely the location of most of the preglacial streams, the drainage of all of which eventually entered the Lake Erie basin. This will be evident from the bedrock surface map by Ver Steeg (1934) which covers a considerable portion of the area.

It is generally agreed that the locations of the present Conotton and Stillwater Creeks are essentially the same as those in preglacial time. The Conotton Creek extended northwestward as far as Clinton in southwestern Summit County, from where it may have continued northward by Akron and along the present Cuyahoga Valley to the Lake Erie basin, or it may have continued northwestward along the

present Chippewa Valley to near Rittman and there turned northward along the old valley east of Rittman and Medina and along the west branch of the present Rocky River to the Lake Erie basin. The Stillwater Creek evidently continued northwestward into the southwest corner of Stark County, where it may have turned east and joined the Conotton; or more probably it continued northwestward across Wayne County and through the valley in which Chippewa Lake is now located and joined the old Conotton River in northwestern Medina County and continued northward into the Lake Erie basin. As already suggested, the drainage in southeastern and central Ohio was northward along the old Teays River and that in western Ohio was likewise northward along the old Hamilton River into the Lake Erie basin.

Indiana Preglacial Drainage

The location of the preglacial drainage in Indiana, and especially in Illinois, is much more difficult to determine than that for Ohio. Geologists generally have considered the Mahomet River as preglacial and have determined the drainage upon this basis. However, Ver Steeg (1934: 611) refers to the old Teays River and states, ". . . from Chillicothe northward its most probable course was to the north through the broad lowlands now occupied by the tributaries of the Scioto River in western Ohio." If the preglacial drainage of the old Teays and other streams in Ohio was northward into the Lake Erie basin, as indicated by the evidence already presented, then the old Mahomet River in Indiana and Illinois was interglacial rather than preglacial. No one seems to have been able to identify definitely any Nebraskan glacial deposits in this old valley. This would seem to indicate that it was of Nebraskan origin. The development of the Lake Michigan basin below the bedrock surface, which surrounds its southern extension, would seem to have required the discharge into it by one or more streams draining rather large areas. This basin would probably have been considerably deepened by the glaciers.

As shown on the bedrock surface map in figure 2, most of the southeastern part of Indiana, except a broad valley known as Scottsburgh lowland which extends northwestward from the Ohio River into the northwestern plains, has an elevation of more than 750 ft and in a few small areas of more than 1,000 ft, while in all of the northern and western parts, and also in the broad valley just referred to, it is less than 750 ft. In the Wabash and old Mahomet Valleys and small areas near Lake Michigan, and also in the northeast section, the elevation is less than 500 ft.

This general northwestward slope of most of the bedrock surface, except the southwestern part, is evidence that most of the preglacial drainage was probably into the Lake Michigan or Lake Erie basin. This would include the drainage of the Scottsburgh lowland, which is underlain by the same geological formation (see fig. 1) as the broad Scioto Valley in Ohio. Both valleys extend northward from the present Ohio River into the lake plains and were apparently formed by streams which flowed northward into the lake basins. This Scottsburgh lowland is bordered on the west by the Knobstone escarpment, which, according to Wayne (1956) ". . . rises 400 to 600 feet above the lowland east of it."

Illinois Preglacial Drainage

The early drainage in much of Illinois is very difficult, or even impossible, to determine. The elevation of the bedrock surface, shown in figure 2, and the probable location of the more important divides, which are indicated on the preglacial map shown in figure 3, are of definite assistance. Much, however, depends on whether the old Mahomet River was preglacial or resulted from the advance of an early glaciation, probably the Nebraskan. Geologists generally have considered it preglacial, but positive evidence that it resulted from the

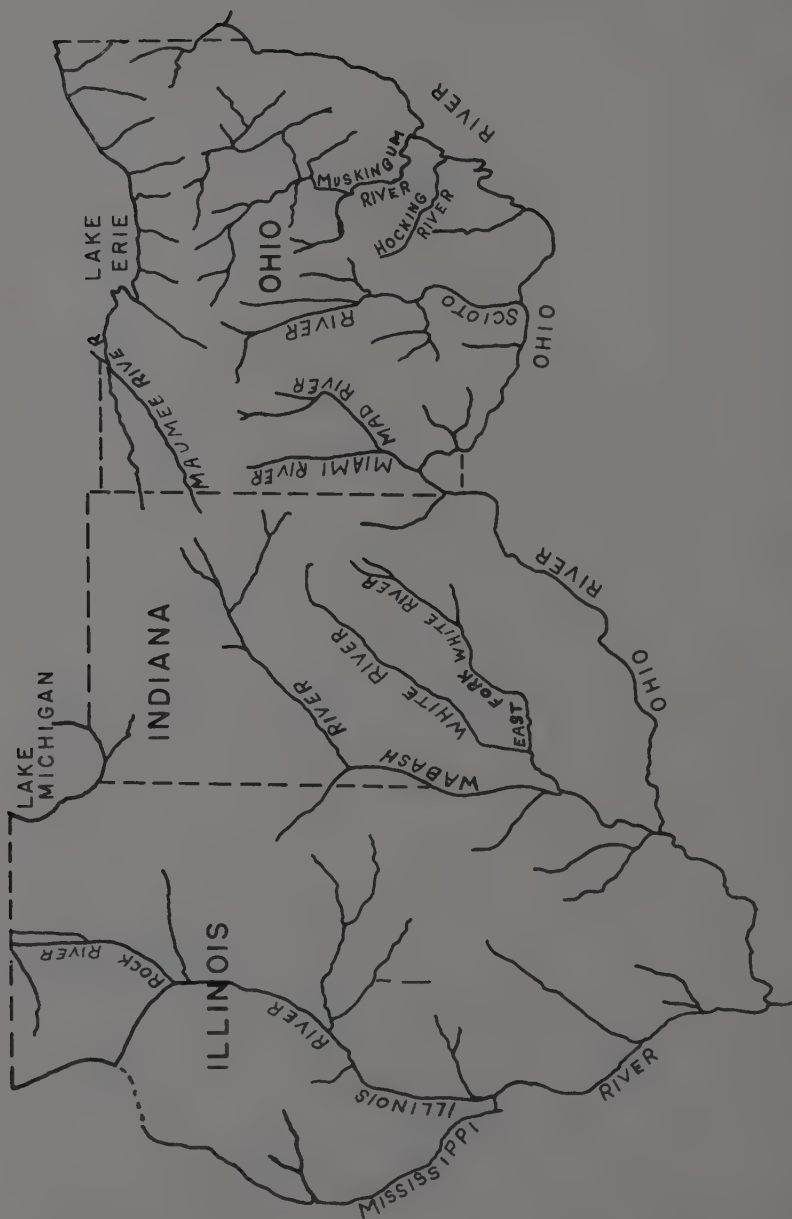


FIGURE 5. Kansan drainage.

advance of an earlier glaciation, probably the Nebraskan, has been previously presented (Coffey, 1930-1958) and in the earlier part of this paper. If the deep valleys in Illinois are interglacial, as the evidence indicates, then the elevation of most of the preglacial bedrock surface in central Illinois may have been 600 ft or more, as indicated by some small areas in this section with an elevation of more than 700 ft.

Practically the entire divide, which extends from Indiana westward across south central Illinois to the Mississippi River, has a bedrock elevation of more than 600 ft, except where it is intersected by the deep comparative narrow valley of the lower Illinois River whose steep bluffs rise to more than 600 ft. The elevation of this divide increases to over 750 ft in the section west of the Illinois River and in a small area in the eastern part.

The present drainage northward from the old divide, except where it is intersected by the lower Illinois River, would seem to indicate that all of the preglacial drainage north of it may possibly have been northward into central Illinois. If this is true, the drainage in the western part was probably northward and then northeastward along the present broadening valley of the Illinois River to central Illinois, where it may have turned southeastward along what later became the old Mahomet Valley and then northeastward and in Iroquois County may have been joined by the northern Illinois drainage and continued into Indiana, where it united with the Indiana drainage and flowed northward into the Lake Michigan basin.

Another possibility, however, is that instead of turning southeastward it continued northward along the present Illinois Valley to Putnam County or northeastward along the valley in western McLean and Livingston counties and in LaSalle County joined the northern Illinois drainage and continued northeastward along an old valley into the Lake Michigan basin. It would probably have been joined in central Illinois by the drainage from the southeast along a section of the later old Mahomet Valley. It is possible also that it may have been joined in Grundy County by the drainage from the southeast toward the Indiana line.

Another possibility, in regard to the drainage north of the divide in south central Illinois, is that from this divide in Vermillion County another preglacial divide probably extended northwestward across what later became the Mahomet Valley in Champaign County and continued northwestward across northeastern McLean and southwestern Livingston counties and across the present Illinois River Valley in Marshall County, in the western part of which, as well as in three small areas in northeastern McLean County, the elevation of the bedrock surface is more than 700 ft. If this truly represents a preglacial divide, then all of the drainage southwest of it and north of the divide in south central Illinois would have been westward and then south along the present Illinois Valley into the Mississippi River; and the drainage north of it would have been eastward into the Lake Michigan basin. The northeastern course of the present Pecatonica River in northwestern Illinois and the angle at which it enters the Rock River may indicate that its preglacial drainage, and possibly that of the upper part of Rock River, may have been northward through Wisconsin into an arm of the old Lake Michigan basin. It may mean also that the Rock River is largely of interglacial origin and that in preglacial time the drainage in the lower section was southeastward to join the old Mississippi River, which may then have flowed northeastward into the Lake Michigan basin or southeastward into Indiana to join the Indiana drainage northward into that basin.

It is, of course, possible that such a preglacial divide did not exist and that all of the preglacial drainage in northern Illinois, except that in the northeastern part which went into the Lake Michigan basin, flowed southward along the present upper Illinois River valley and in the central part was joined by drainage from the east central part and turned southwestward and then south along the present

Illinois Valley, which gradually decreases in width from a broad valley in central Illinois to a comparatively narrow one with steep bluffs before entering the Mississippi River. This could have been true, although the preglacial valleys were evidently greatly deepened and broadened after the advance of an early glaciation and the formation of the Mahomet River.

The possible different preglacial drainages which have been suggested indicate the great difficulty, or even impossibility, of determining definitely the location of even the major preglacial streams in Illinois. The streams, which the evidence seems to indicate as those most probably representing the preglacial drainage, are shown in figure 3. This map represents the preglacial drainage as being prior to the formation of the Mahomet River. Horberg (1950) considers it practically the same as the Nebraskan glacial map in his article.

Advance of the Glaciers

During the Pleistocene Epoch the preglacial and interglacial drainage was greatly changed by the advance of the different glaciations, of which there were at least four, the Nebraskan, Kansan, Illinoian, and Wisconsin. It has been estimated that the Nebraskan glaciation was probably one million or more years ago and that thousands of years intervened between each advance but only the preglacial, Nebraskan and Kansan drainage is being considered in this article.

During the Pleistocene Epoch the ice advanced from the northeast through the Lake Erie Basin and from the north along the Lake Michigan basin and possibly between these two from the Lake Huron basin; and advanced from the northwest in west central Illinois and covered most of the area of the three states, except the southeastern part of Ohio, the southwestern part of Indiana, and the southern and extreme northwestern parts of Illinois. The advance of the different glaciations, especially the earlier ones, produced many major, and numerous minor, changes in the preglacial drainage but it is often difficult, or even impossible, to determine the location of the preglacial and early interglacial streams. "Many changes, especially drainage modifications, are apparent in wide areas, are sufficiently old in point of physiographic history and are difficult to account for on any other assumption than the effect of an early glacier" (Stout and Lamb, 1939).

Nebraskan Glacial Drainage

The generally southwestward, or southward, advance of the Nebraskan glaciation over much of northern Ohio, Indiana, western and possibly northeastern Illinois has been generally accepted, although the materials which were deposited by it have practically all been removed by the advance of the later glaciations; so that it is not possible to determine definitely the southern limit of the area covered by it. In Ohio it was probably halted by the rapid increase in the elevation along the northwestern extension of the Allegheny Plateau. The location of the old Mahomet Valley, which, positive evidence indicates, was brought about by the advance of the Nebraskan glaciation, helps in determining its limits. As the glacier advanced it blocked all northward preglacial drainage into the Lake Erie and Lake Michigan basins and forced the streams to reverse along old channels, or to develop new ones. The principal Nebraskan glacial drainage is shown in figure 4. In Illinois this is practically the same as the preglacial and Nebraskan drainage by Horberg. After the retreat of the glacier much of the drainage in the northern section, especially in Ohio, again flowed northward into the old lake basins.

Ohio Nebraskan Drainage

The advance of the Nebraskan glacier in Ohio and in most of Indiana was from the northeast along the old Lake Erie basin from which it spread southward, tending to flow around the higher areas and to spread out like fans from the larger valleys. Goldthwait has estimated that the advance of the same glacier at fastest

known speed took 5,000 years to cross the state the first time. As the glacier advanced from the northeast it would have blocked the Lake Erie drainage and have resulted in an increase in the level of the lake to an elevation of 600 or 700 ft, when it broke over into Indiana and continued until the glacier advanced to the higher lands on the south.

When the ice advanced south far enough to encounter the northern end of the divide, which extends north from the Ohio River in Monroe County to Geauga County and forms the western boundary of the Grand River Basin, it blocked the northward Pittsburgh and northeastern Ohio drainage and formed a lake, which continued to rise and back up until it reached the lowest elevation in the old divide along its western border, which was probably at least 1,100 ft, and broke over just south of Ravenna (Coffey, 1914, 1930). The drainage may have flowed northward along the old Ravenna River (Scranton and Lamb, 1932), and later joined the drainage in the old Cuyahoga Valley and continued northward into the glacial lake which had risen until it overflowed into Indiana at an elevation probably around 650 ft. As the glacier continued southwestward very slowly, it would have gradually blocked any northward drainage and after probably more than 1,000 years would have included that of the old Cuyahoga Valley and also that of the old Grand River valley, which had broken over the divide near Ravenna.

The changes in the drainage in the present Cuyahoga and upper Tuscarawas drainage basins have probably been greater and the valleys more deeply eroded than those in any other section of Ohio, as may be seen from the map by Ver Steeg (1934). In the Cuyahoga Valley about 15 miles east of Independence Ver Steeg (1938) secured data showing, "... the floor of this valley lies 13 feet below sea level." According to Winslow, White, and Webber (1953), "... well records in Cuyahoga River Valley indicate the valley floor to be 100 feet or more below sea level near Gordon Park at the Lake Shore." In the Chippewa Valley in northeastern Wayne County borings showed the depth to the rock surface to be as much as 417 and 443 ft, or approximately 50 ft below the level of Lake Erie. The formation of these and other deep valleys may indicate a rise of the land and erosion by the streams or glaciers, or by both.

As the ice came from the northeast, it would have advanced along the old Cuyahoga Valley before reaching the areas west; and this would have blocked not only the drainage in the old Cuyahoga Valley but also the Pittsburgh drainage, which had broken over the divide near Ravenna. This may have resulted in turning the Pittsburgh drainage southwestward and in the formation of an old valley from near Ravenna by Fitch and Portage Lakes into the present Tuscarawas Valley, as suggested personally by Lamb.

The blocking of the northward drainage had resulted in the formation of a lake, which continued to rise and advance southward until it reached the preglacial Tuscarawas drainage and joined with it. Then it turned northwestward along the present Chippewa Creek in northeastern Wayne County and continued northwestward along an old stream east of Rittman and Medina and was probably principally responsible for the deep erosion that resulted.

As the glacier moved slowly southwestward, it would have blocked this stream and successively have joined and then blocked other streams, which formed the old valleys shown on the map by Ver Steeg (1934), until the glacier had moved far enough southwest to block all of the streams and result in their reversal, or in the formation of other streams, which flowed southward and became part of the present Tuscarawas drainage system, or formed the Mt. Vernon River as described by Dove (1960), which may have extended southwestward from Wayne county by Perrysville and Mt. Veronon to join the Cambridge River in northwestern Fairfield county, and then continued and joined the Teays River in Pickaway county. It is possible, of course, that some of these changes were brought about

by later glaciations, especially the Kansan, but the evidence indicates that the most important changes in northern Ohio resulted from the advance of the Nebraskan glaciation.

As the glacier had blocked all northward drainage in this section, the lake continued to rise along the old Conotton, now the Tuscarawas Valley, until near Brewster it broke over the divide between the old Conotton and Stillwater valleys and followed the latter to beyond New Philadelphia. Continuing to rise, the lake extended southwestward until it reached an elevation of 1,100 or 1,200 ft and near Port Washington it broke over the divide, which extends northwestward from Monroe County, and cut out a wide gorge now occupied by the Tuscarawas River. The present Tuscarawas Valley through this old divide is approximately twice as wide as the present Ohio Valley. If, as the evidence indicates, the drainage that broke over this divide included the Pittsburgh and eastern Ohio drainage, as well as that of most of northeastern Ohio, which had formed a large lake, the formation of this unusually wide valley would apparently be explained. The stream thus formed flowed southwestward and then westward and was joined by a stream from the southeast and continued by Coshocton and probably Newark, and joined the old Teays drainage in the old Scioto Valley.

Since it has been estimated that the advance of the glacier southwestward across Ohio probably took 5,000 years, it is possible that it had not yet reached the upper Scioto Valley and that the drainage along this valley was still northward into glacial Lake Erie, until the glacier had moved far enough south to encounter the highlands in Logan County and thus to block all northward drainage along what is now the Upper Scioto Valley.

The drainage thus blocked would have included not only all that of the old Teays River in southeastern Ohio, much of West Virginia and eastern Kentucky, smaller amounts from Virginia and North Carolina west of the Blue Ridge Mountains, but also that from northeastern Ohio and western Pennsylvania, as already outlined.

The blocking of the drainage in the old Teays Valley would have resulted in the formation of a glacial lake, which would have risen and backed up the drainage along the other valleys for many miles until it reached the lowest points in the divide along the west side of the old Teays Valley, which was apparently in Madison, Clark, and Champaign Counties, where it broke over and continued northwestward, was joined by the old Hamilton drainage, the north part of which was blocked by the glacier, and was forced to turn west and enter Indiana. Some of the silts along the old Teays River and its tributaries were probably deposited during this backing up of the drainage by the Nebraskan glaciation, but later deposits were doubtless made during the Kansan glaciation.

Indiana and Illinois Nebraskan Drainage

The advance of the ice southwestward along the Lake Erie basin and south along the Lake Michigan Basin forced all drainage in Indiana and Illinois, which had been northward or northeastward into these basins, to join that from Ohio and thus to form what is known as the Mahomet, or Mahomet-Teays River. This Mahomet River represented an extension of the old Teays River from the old Scioto Valley in Ohio, northwestward across western Ohio, and westward across Indiana and westward to central Illinois, where it united with the old Mississippi drainage and formed the present Illinois River.

Since this old Mahomet River would have included not only the drainage of the old Teays River and other streams which had been forced to join it, but also the Hamilton River in western Ohio and all streams in northern and central Indiana and Illinois, including the old upper Mississippi River, it must have been a large stream, which, during the thousands of years that intervened before the Kansan glaciation reached this section, would have eroded a deep valley, much of which has been largely filled by the Kansan and later glaciations.

After the retreat of the Nebraskan glaciation, much of the drainage in northern Ohio and northeastern Indiana apparently returned to the Lake Erie basin; but very little of that in Indiana and Illinois returned to the Lake Michigan basin. Most of it continued along the old Mahomet River. It is possible that the old Pittsburgh drainage continued across the divide south of Ravenna until the advance of the Kansan glaciation, but it may have resumed its preglacial channel northward through the Grand River valley into the Lake Erie basin.

Kansan Glacial Drainage

The Kansan glaciation advanced principally from the northeast and north, except in west central Illinois where it came from the northwest. It extended much farther south than the Nebraskan. Both the Lake Erie and Lake Michigan sections moved southward until they blocked all northward drainage, especially that of the old Mahomet-Teays River and its numerous tributaries, which included most of the drainage in the three states being considered. This blocking of the drainage resulted in the elimination of the Mahomet River, the reversal of many streams and in the formation of new ones, including the present Ohio River, and in the deepening of many old valleys. Evidence indicates that the old Mississippi River was not materially affected but that it continued to flow southward through most of the present valley of the Illinois River.

The drainage which developed in the deep interglacial valleys has been referred to as "Deep Stage" by Stout and Lamb (1939: 22). Since the advance of the Kansan glaciation apparently blocked most of the drainage and at least partially filled some of the deep valleys, like the Mahomet, with glacial deposits, deepened some of the old valleys, like the present Scioto and Miami, and also formed new ones, like the Ohio, the "Deep Stage" should probably be divided into two stages, the Nebraskan, or Mahomet River stage and the Kansan, or Ohio River stage.

Formation of the Ohio River

The advance of the Kansan glaciation apparently first blocked the old Pittsburgh and eastern Ohio drainage in the present Grand River Valley. This resulted in the formation of a lake which rose until it broke over the divide in Monroe County and joined the southwestward flowing stream. Continuing southwestward and uniting with the old Teays River, it continued along this old stream westward and then northwestward to near Wheelersburg, thus forming this section of the present Ohio River, which eventually became the southeastern boundary of Ohio.

The advance of the Kansan glaciation southwestward, by blocking the drainage in the old Teays Valley, resulted in the formation of a lake which rose until it broke over the divide west of Wheelersburg and continued westward by Portsmouth. There it broke over the old divide in southern Adams County and continued northwestward to near Cincinnati, thereby forming most of the southwestern section of the present Ohio River. Near Cincinnati it joined the old Little Miami River, then turned west by Norwood where it joined the old Licking River and, continuing northwestward to south of Hamilton, it joined the old reversed Hamilton River, now the Miami River, and followed it beyond where the present Ohio River joins it. The section of the Ohio River south of Cincinnati was apparently formed by the later Illinoian glaciation.

The Hamilton section of the new Ohio River continued southwestward and broke over the divide near Madison, Indiana, and then continued until it reached the Scottsborough lowland, which, as already pointed out, has an escarpment along its western border (Wayne, 1956) that rises 400 to 600 ft above the lowland east of it; and near the Ohio River west of New Albany it has the largest area in Indiana where the elevation of the bedrock surface is more than 1,000 ft (fig. 2). Since

this escarpment would evidently have blocked the new Ohio River drainage, it apparently turned northward into the Scottsborough lowland where, in the southern part as will be explained later, it probably remained until the advance of the Illinoian glaciation forced it to break over the escarpment southwest of New Albany. Then it continued southwestward to the Mississippi River, thereby forming the present southern boundary of Indiana and Illinois. The elevation of the bedrock surface of the Mississippi River at this junction is less than 200 ft above sea level.

Ohio Kansas Drainage

The advance of the Kansas glaciation southward possibly caused more important changes in the drainage in Ohio than that of any other glaciation. It blocked all northward drainage into the Lake Erie basin and also that of the old Mahomet-Teays River and its many tributaries.

Attention has already been called to the blocking of the old Pittsburgh and eastern Ohio drainage and its breaking over the divide in Monroe County. That the breakover of this divide in Monroe County was later than that over the divide near Port Washington in Tuscarawas County is evidenced by the difference in the pattern of the contours east and west of the divide, which separates the drainage between the Ohio and Tuscarawas Rivers, sometimes referred to as the Flushing Escarpment. According to Stout and Lamb (1939: 5), "The pattern east of the escarpment in this respect lacks the deep indentations of that to the west. Thus the surface east of the escarpment in contrast to that to the west, has wider ridges, less direct relief, fewer small streams, and in general more uniformity." This difference in surface conditions furnishes positive evidence that the breakover of the divide near Port Washington by the Tuscarawas River was during an early glaciation, probably the Nebraskan, while that of the divide along the present Ohio River in Monroe County was during a later glaciation, probably the Kansan.

Although the present Tuscarawas River continues southwestward through the old divide near Port Washington, according to Ver Steeg (1934: 613), "... the bedrock slope of the buried valley of this stream is to the north," and has been termed the Cleveland River by Stout and Lamb (1939: 25). This seems to indicate that, following the retreat of the earlier glaciations, the Tuscarawas drainage east of this divide was again northward and contributed to the formation of the deep bedrock valleys in this northeast section of Ohio.

Evidence indicates that the advance of the Kansan glaciation was far enough southeastward to have blocked the old Tuscarawas River, possibly in Licking County, and resulted in the break over of the col near the Muskingum-Morgan county line and in the formation of the present Muskingum River; also, that it blocked other westward drainage and resulted in the formation of the present Hocking River and other smaller streams.

Hubbard (1954) states, the "... col at Blue Rock was before the Illinoian glacier came, and was probably initiated by the Kansan or Nebraskan ice sheet." He also states, "... there are terraces on the Muskingum of at least three ages, Wisconsin, Illinoian, and an older stage probably Kansan" and also the findings "... established the Hocking streams adjustments as pre-Illinoian." These terraces are above the present flood-plain terraces. The diversion of water over the col below Blue Rock must have been early enough to have enabled the new through stream to carry Kansan outwash and lay it along the valley.

In *What the Glaciers Did to Ohio*, Goldthwait estimated "... this creeping sea of ice must have ground over Ohio slowly too; at fastest known speed it took 5,000 years, just to cross the state the first time." It would seem, therefore, that possibly the section of the new Ohio River east of Wheelersburg was formed a thousand or more years before the glacier, probably the Kansan, blocked the old Mahomet-Teays River in western Ohio, and that the newly formed Ohio River

continued northward along the old Mahomet-Teays River until this stream was blocked by the advance of the Kansan glacier, which was probably first in the old Hamilton valley in western Ohio, as indicated by the location of the moraines and by the Mahomet-Teays River being much farther north in the old Hamilton valley in western Ohio than in the Scioto valley. As the glacier moved farther southward, it would have resulted in the backing up of the drainage in the old Mahomet-Teays River until it probably broke over in Clarke County and formed the present Mad River which flowed southward and joined the old reversed Hamilton River. This may have formed the Ohio River west of Cincinnati before the advance of the ice farther southward forced a breakover west of Wheelersburg and Portsmouth which extended westward and united with the old Hamilton River north of Cincinnati.

The blocking of the old Teays drainage would have resulted in the formation of a lake, or lakes, which would rise until they broke over the divides on the west to form the present Ohio River, except south of Cincinnati, which was formed later. Since this new Ohio River was a large stream, it would have rather rapidly lowered its channel, thereby, making it possible for the streams in the old Hamilton and Teays valleys to be reversed and form the present Scioto and Miami Rivers, and gradually lowering the surface in these valleys so that it now slopes toward the south instead of toward the north as was previously the case.

The backing up of the drainage in the old Teays valley made possible the deposition of the silts in this old valley and its tributaries. Some of the materials in these silts came from as far south as North Carolina, having been transported northward by the old Teays River, now the New River, which rises near the crest of the Blue Ridge Mountains, about 2 miles northeast of Blowing Rock. Since the present Yadkin River rises just east of the crest, within approximately a half mile of the New River, and rapidly descends 1500 or 2000 ft before entering the Piedmont Plateau, it does not seem possible that the old Teays River "gathered its headwaters out in the Piedmont Plateau" as has been suggested in several articles by different authors, or that "the high content of sericitic mica indicates that the Minford silts were derived largely from the schists of the Piedmont and therefore the streams headed well out on this old highland," as stated by Stout and Lamb (1938), since this could have come from the gneisses and schists which, according to the geological report and map of North Carolina by Stuckey and Steel (1953), "... underlie much of the Blue Ridge Mountains ..." and in fact practically all of the western part of the state.

Indiana Kansan Drainage

The Kansan glaciation in Indiana extended southward and covered practically all of the northern and central part of the state, evidenced by the presence of deposits definitely determined to be of that age (Wayne, 1956). These deposits are formed in many sections, including the Mahomet Valley, but no deposits of Nebraskan age have been found there.

The drainage in the old Mahomet River in Indiana was probably blocked first in the western part of the state by the advance southward of the Lake Michigan lobe of the Kansan glaciation. This may have been before or after the advance northward of the new Ohio River drainage along the Scottsburgh lowland. The blocking of the Mahomet drainage would have resulted in its backing up until it probably broke over the divide on the south near the Illinois line and joined the old Wabash River and continued southward along this old stream into what probably later became the Ohio River. After the retreat of the glacier, it apparently received most of the drainage in northern Indiana, now included in the upper Wabash basin and some of the drainage in east central Illinois.

The new Ohio River drainage apparently continued northward along the Scottsburgh lowland, which has an elevation of 600 to 700 ft, until it was blocked

by the southward advance of the Kansan glaciation, which had formed a lake that rose until it broke over the knobstone escarpment on the west and apparently formed the present White River, which has a narrow valley through the escarpment. As the glacier continued southward beyond this breakover, the lake rose and broke over the escarpment a second time and formed the East Fork of the White River. This offers an explanation of the present peculiar extension of these streams across the Scottsborough lowland and their breaking through the high escarpment along its western border, which is difficult to explain otherwise.

It is possible that the Ohio River drainage continued through the latter breakover until it was blocked by the Illinoian glaciation; and then it broke over the divide near New Albany and continued southwestward to the Mississippi River. If true, it would help explain the uniting of the present drainage from the north and east just west of a small remnant of the escarpment, and the formation of a rather wide deep valley through the escarpment (fig. 2) and in the area to the west, which is still occupied by the East Fork of the White River. It might also explain why there is very little drainage from this lowland into the present Ohio River (Wayne, 1956: 27).

Illinois Kansan Drainage

The Kansan glaciation in Illinois advanced from both the northeast and the northwest and covered most of the state of Illinois, except the southern and northwestern sections. According to Horberg (1950), the north eastern Labradorean, or Lake Michigan lobe, extended southwestward practically to the present Rock, Illinois, and old Mississippi Rivers, and southward as far as a line extending southwestward across the state from Crawford to Randolph County. The Keewatin lobe entered the state from the northwest and covered practically all of the section west of the present Illinois River. The meeting of the two advances from different directions followed rather closely that of the old Mississippi River and apparently produced no major changes in its drainage unless it be in eastern Tazewell County, where it may have blocked the old Mississippi River, resulting in the formation of the present Illinois River along the western boundary of this county.

The most important change in the drainage in Illinois which resulted from the advance of the Kansan glaciation was the blocking of the Mahomet River and its tributaries, which included most of the drainage in east central Illinois. According to Foster and Buhle (1951), "... it appears likely that the Kansan drift completely filled the deep channel of the Mahomet Valley and most of the Havana strath. Kansan thicknesses probably range from zero to a maximum of 25 ft over the lowest bedrock elevations west of Champaign." They also state, "... no deposits suggesting Nebraskan origin have been discovered in the strath area west of Champaign." If the Mahomet River were formed by the advance of the Nebraskan glaciation, as suggested, there would have been no glacial deposits of this age in this old valley. This absence of Nebraskan deposits tends to confirm the suggestion that the Mahomet Valley was interglacial rather than preglacial in origin. Some of the smaller streams in east central Illinois, which now join the Wabash River, as well as in other sections of the state, were probably formed by the advance of the Kansan glaciation, or possibly by later glaciations.

REFERENCES

- Carman, J. E. 1946. The geological interpretation of scenic features in Ohio. *Ohio J. Sci.* 46: 241-283.
Chamberlain, T. G. and F. Leverett. 1894. Further studies of the drainage features of the upper Ohio basin. *Am. J. Sci.* 47: 247-283.
Coffey, G. N. 1914. Changes of drainage in Ohio. *Science*, new series 40: 607-609.
— 1930. Preglacial, interglacial and postglacial changes in drainage in northeastern Ohio with special reference to the upper Muskingum drainage basin. *Ohio J. Sci.* 30: 373-384.

- . 1958. Major glacial changes in Ohio. *Ohio J. Sci.* 58: 43-49.
- Cummings, J. W. 1959. Map of probable surface of bedrock underlying glaciated area in Ohio. *Ohio Water Plan Inventory Report* 10, Plate 1.
- Dove, G. D. 1960. Drainage of Teays stage of Mount Vernon and Cambridge Rivers. *Ohio J. Sci.* 60: 122-124.
- Eveland, H. E. 1952. Pleistocene geology of the Danville region. *Ill. Geol. Surv. Report Inventory* 159: 32 pp.
- Fidler, M. M. 1943. The preglacial Teays Valley in Indiana. *J. Geol.* 51: 411-418.
- Foster, J. W. and Merlyn B. Buhle. 1951. An integrated geophysical and geological investigation of aquifers in glacial drift near Champaign-Urbana, Ill. *Econ. Geol.* 46: 367-397.
- Goldthwait, R. F. What the glaciers did to Ohio. *Ed. Leaflet Ser.* 3: 31 pp.
- Horberg, L. 1950. Bedrock topography of Ill. *Ill. J. Geol.* 54: 3.
- . 1950. Bedrock topography of Ill. *Ill. Geol. Surv. Bull.* 73. Map of 2nd ed., Plate 1, 1957.
- Hubbard, G. D. 1954. Terrace interpretation in southeastern Ohio. *Ohio J. Sci.* 54: 967-977.
- Lessig, H. O. 1959. The supermarket terrace near East Liverpool, Ohio. *Ohio J. Sci.* 59: 332-338.
- Leverett, F. 1897. Changes of drainage in southern Ohio. *Dennison Univ. Sci. Lab. Bull.* 9, Pt. 2, No. 3.
- . 1902. Glacial formations and drainage features of the Erie and Ohio basins. *U. S. Geol. Surv. Monogr.* 41: 802 pp.
- Merrill, W. M. 1953. Pleistocene history of a part of the Hocking River valley, Ohio. *Ohio J. Sci.* 53: 143-158.
- Norris, S. E. and H. C. Spicer. 1958. Geological and geophysical study of preglacial Teays valley in west central Ohio. *Geol. Surv. Water-Supply Paper* 1460 E.
- . 1959. Buried topography and its relation to an important aquifer in Franklin County, Ohio. *Ohio J. Sci.* 59: 341-343.
- Scranton, R. and G. F. Lamb. 1932. Ancient drainage between the old Cuyahoga and the old Pittsburg Rivers. *Ohio J. Sci.* 32: 481-486.
- Selkregg, Lidia F. and J. E. Kempton. 1958. Ground water geology in east-central Illinois. *Geol. Surv. Circ.* 248: 36 pp.
- Shepps, V. C., G. W. White, J. B. Droste, and R. F. Sitler. 1959. Glacial geol. in northwestern Pennsylvania. *Penn. Geol. Surv. Bull.* G-32. Map.
- Stout, W. and G. F. Lamb. 1938. Physiographic features of southeastern Ohio. *Ohio J. Sci.* 38: 49-83. Reprint Series No. 1, 1939.
- , K. Versteeg, and G. Lamb. 1943. Geology of water in Ohio with map of bedrock surface. *Geol. Surv. Ohio, 4th Ser., Bull.* 44: 69-83.
- Stuckey, J. L. and W. G. Steel. 1953. Geology and mineral resources of North Carolina. *Educational Series* No. 3.
- Thornbury, W. D. 1948. Preglacial and interglacial drainage of Indiana (abstr.): *Geol. Soc. Am. Bull.* 59, p. 1359.
- Ver Steeg, K. 1930. Drainage changes in the vicinity of Wooster, Ohio. *Ohio J. Sci.* 30: 309-314.
- . 1931. Drainage changes in the vicinity of Loudonville, Ohio. *Ohio J. Sci.* 31: 368-376.
- . 1934. Buried topography of north central Ohio. *J. Geol.* 42: 602-620.
- . 1936. Buried topography of western Ohio. *J. Geol.* 44: 318-339.
- . 1946. The Teays River. *Ohio J. Sci.* 46: 297-307.
- Wayne, W. J. 1956. Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary. *Indiana Dept. Conser. Geol. Surv., Report of Progress* 7: 1-70.
- White, G. W. 1934. Drainage history of north central Ohio. *Ohio J. Sci.* 34: 365-382.
- Winslow, J. R., G. W. White, and E. C. Webber. 1953. Water resources of Cuyahoga County. *Bull.* 26: Dept. Nat. Resources, Div. Water, 133 pp.

Apical Meristems. F. A. L. Clowes. Blackwell, London. 1961. 217 pp. \$5.28.

This book is a masterful synthesis and critical evaluation of most of the important literature directly and indirectly related to apical meristems. The material is presented clearly and precisely. Concepts and relationships fundamental to an understanding of (1) stem and root growth in length and diameter, (2) leaf and bud origin, rates of growth, and physiology, (3) the origin and developmental anatomy of chimerae, and (4) the genetics and biochemistry of organ, tissue, and cell differentiation, are presented in such a way that their significance may be readily appreciated by the forester, horticulturalist, plant physiologist, geneticist, ecologist, biochemist, developmental anatomist, and the general botany instructor.

RICHARD A. POPHAM

THE CAMBIUM CURCULIO, *CONOTRACHELUS*
ANAGLYPTICUS (SAY), ON COLUMBINE
(*AQUILEGIA* SP.) IN OHIO

C. R. NEISWANDER

Ohio Agricultural Experiment Station, Wooster, Ohio

A number of years ago severe injury to columbine (*Aquilegia* sp.) was observed in an estate garden at Chagrin Falls, Ohio. The injury occurred at the base of the plant slightly below the soil surface where the interior of the stem was eaten away by the larvae of a curculionid beetle. As many as 18 grubs were taken from a single clump. In cases of severe injury, the entire plant was killed and could be lifted from the ground with but little effort. Because of the injury, which occurred in July and early August, the gardener maintained that he was unable to grow columbine as a perennial but had to start new clumps every year.



FIGURE 1. Injury to columbine caused by larvae of cambium curculio.

Field-collected larvae were reared to adults and were identified by L. L. Buchanan of the U. S. National Museum as *Conotrachelus anaglypticus* (Say). Injury of this type is unusual for this species which gets its common name from the fact that it ordinarily feeds under the bark of various fruit and shade trees. The nature of the injury caused to columbine clumps is shown in figure 1.

LITERATURE CITED

Schoof, H. F. 1942. The genus *Conotrachelus* Dejean (Coleoptera, Curculionidae) in the north central United States. Illinois Biol. Monogr. 19: 1-170.

THE OHIO JOURNAL OF SCIENCE 61(5): 314, September, 1961.

STRATIGRAPHY AND AGE OF DEPOSITS IN AN EXCAVATION AT THE WRIGHT-PATTERSON AIR BASE, DAYTON, OHIO

JANE L. FORSYTH
Ohio Geological Survey, Columbus, Ohio

Excavation on the upland at the Wright-Patterson Air Force Base near Dayton during the winter of 1957 revealed a sequence of Pleistocene deposits, including a till containing fragments of wood. Because information provided by this excavation would be available for only a short time, the geologic section was observed; wood from the till was collected, identified, and a radiocarbon age determination made; and moss from a silt beneath the wood-bearing till was also identified. The purpose of this report is to present briefly and to evaluate all the data concerned with this excavation.

Location

The excavation was made on the upland south of old Ohio route 4 at the Wright-Patterson Air Force Base near Dayton, in the south-central part of section 12, R7T2, Beaver Creek Township, Greene County, Ohio. It was observed and sampled on February 5, 1957, by Andrew Spieker of the U.S. Geological Survey, Ground Water Branch, in Columbus, Ohio, and by myself.

Geologically, this site lies on ground moraine in the southeastern part of the Miami glacial lobe (see fig. 1), southeast of the Farmersville moraine and north of a small east-west moraine considered to be equivalent to the Camden moraine (Goldthwait, 1950). Bedrock (Ordovician upper Richmond and Silurian Brassfield) is shallow in this upland area.

Stratigraphy

The section exposed in this excavation includes six Pleistocene units underlain by Ordovician bedrock:

No.	Description	Thickness
7.	Sand and gravel, well sorted, coarse, discontinuous.	0-8 ft
6.	Till, oxidized 3-7 ft; rounded masses of silt from unit 3, 4-12 in. in diameter, are present within the base of this unit. Wood in the form of good-sized logs, branches, and smaller fragments occurs in the basal few feet of this till. Wood sample taken from this till was identified as <i>Picea</i> (spruce) by Dr. G. W. Burns and dated at 21,600 $\pm$ 400 (W-648) radiocarbon years.	6-11 ft
5.	Clay, gray.	0-6 in.
4.	Peat.	$\frac{1}{8}$ - $\frac{1}{4}$ in.
3.	Silt, with occasional gastropod shells, wood fragments, and moss identified as <i>Drepanocladus apiculatus</i> Steere by Dr. Margaret Fulford. Source of rounded masses in base of unit 6.	4-14 in.
2.	Sand with lenses of pea- or coarser-sized gravel, very dirty and poorly sorted; locally contains a thin zone of what appears to be sandy till.	3-6 ft
1.	Ordovician Richmond shale.	

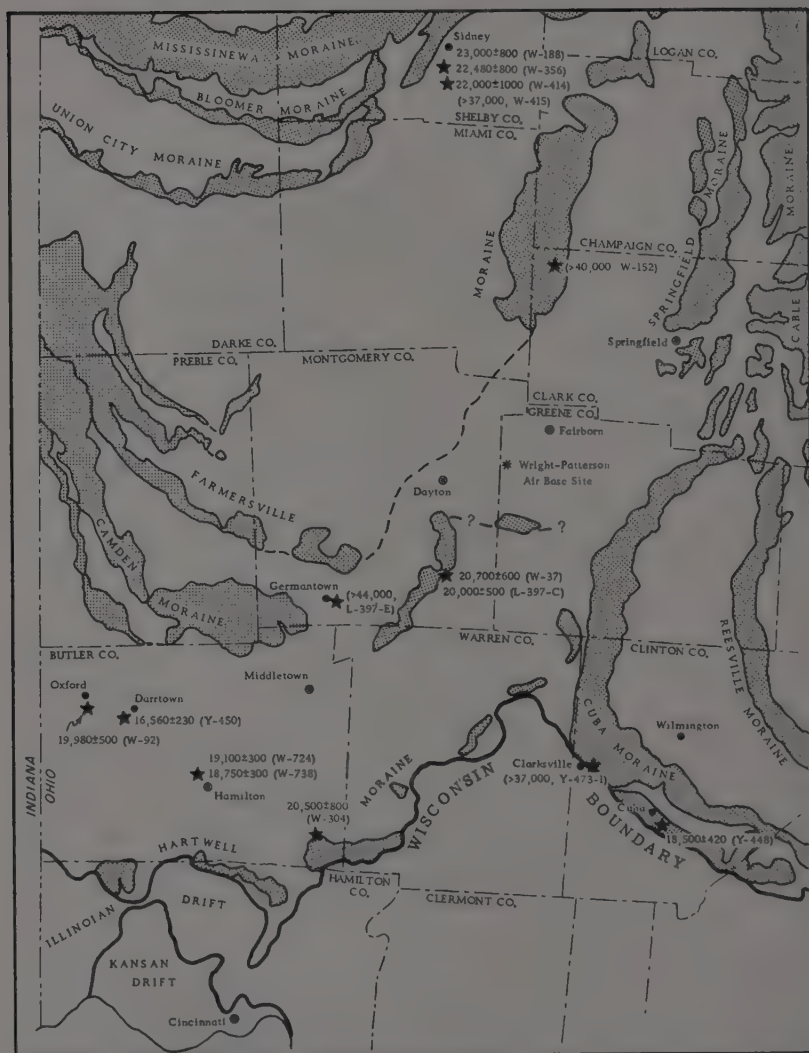


FIGURE 1. Map showing general location of site with respect to glacial boundaries, Wisconsin end moraines, and other localities from which have come wood that has been dated.

Discussion

The till containing the wood is part of the extensive till deposit which blankets much of southwestern Ohio and was left by the last major advance of the Wisconsin glacier. Radiocarbon dates from wood embedded near the base of this surface till have been obtained from many localities in central and western Ohio (see fig. 1; see also Goldthwait and Burns, 1958). Thus, a series of stages in the advance of this glacial front can be traced: from the edge of Lake Erie near Cleveland ($24,600 \pm 800$, W-71) south to Columbus $23,000 \pm 850$, Y-449) and Sidney ($23,000 \pm 800$, W-188), on to Chillicothe ($18,050 \pm 400$, W-91), Hamilton ($19,100 \pm 300$, W-724), and Oxford ($19,980 \pm 500$, W-92) (Flint, 1955a, 1955b; Goldthwait and Burns, 1958; Forsyth, 1961). The retreat of this glacier is not recorded; a retreating glacier does not override trees.

The deposition of the till in this exposure, from which the wood was recovered, began, therefore, with the last advance of the Wisconsin glacier into this area about 21,000 years ago. The deposition continued while the glacier advanced on southward to its terminal position near Sharonville (north of Cincinnati) and then began its retreat. This retreat started in the southwest about 17,000 years ago and continued to about 13,000 years ago, when the margin had retreated out of northern Ohio. As a result, the wood-bearing till in this excavation probably represents glacial deposition of from about 21,000 to about 16,000 years ago.

Earlier advances of the ice doubtless covered this area; a thin zone of what may be sandy till is recorded in unit 2. However, possibly because the bedrock surface stood so high in this area, no significant deposits of the earlier glacial advances were left at this site. The lower stratigraphic units (nos. 2(?), 3, 4, 5) seem to be mainly proglacial deposits relating to the advancing glacier that later left the till (unit 6). The presence of the moss *Drepanocladus apiculatus* Steere, which is common in swampy places in Canada and northern United States, indicates a climate at that time that was cool and moist, suggestive of the presence of an advancing glacier.

The overlying sand and gravel (unit 7) probably represents some local outwash deposited by the retreating glacier.

REFERENCES CITED

- Flint, R. F. 1955a. Rates of advance and retreat of the margin of the late-Wisconsin ice sheet. *Am. J. Sci.* 253: 249-255.
———. 1955b. Radiocarbon dates of pre-Mankato events in eastern and central North America. *Science* 121: 649-658.
Forsyth, Jane L. 1961. Dating Ohio's Glaciers. Ohio Geol. Surv. Information Circular No. 30.
Goldthwait, R. P. 1950. Wisconsin Glacial Deposits, in *The Water resources of Greene County, Ohio*. Bull. Div. of Water, Dept. of Nat. Res. 19: 13-19.
——— and Burns, G. W. 1958. Wisconsin age forests in western Ohio. *Ohio J. Sci.* 58: 209-230.

of grasses), grasses, pteridophytes, legumes, and composites, respectively, listing county records for each species of these groups. These records, in turn, are based on information contributed by curators of the various herbaria in the state. A total of 1203 species is reported.

In the catalog of Ohio plants published by Schaffner (1932), a known flora of 2309 species is listed for the state. The pteridophytes, monocots, legumes, and composites constitute 45 percent of these species. A projection based on this percentage and the 1203 species now reported for these same taxa suggests that the total vascular plant flora of Ohio will prove to consist of about 2700 species.

At the county level, the total number of pteridophyte, monocot, legume, and composite species reported ranges widely, from 43 species for Van Wert County to 523 species for Erie County. In all probability the amount of collecting done in these selected taxa is an accurate sample and indication of the total amount of collecting that has been done in each county.

In the list below, counties are arranged in order of the number of species reported. In both the list and the map (fig. 1), counties are divided into four groups. For each of these four groups an estimate is made of the number of species of all vascular plants that have been collected to date. This estimate is based on the assumption that the species reported represent 45 percent of the total, as noted above.

I am aware of several points at which error could affect these figures, principally: misidentification of the specimen, and failure of all Ohio collections to be included. Furthermore, no allowance is made for collecting done after the reports were prepared, an example being the extensive collecting done by Dr. Ervin Herrick in northeastern Ohio. In addition, there is no reason to assume that the floras of all counties are equally rich in numbers of species. Nevertheless, I feel that this list and map provide a good *general* indication of what has been done in Ohio and of which areas are most in need of attention. Certainly those areas of the state shown in darkest color on the map are in need of competent field work before any definitive statement can be made concerning the nature of the flora of Ohio as a whole.

LIST OF COUNTIES

A. *Counties with 351 to 523 species (of pteridophytes, monocots, legumes, and composites) reported.* Estimated number of species of all vascular plants collected: 780 to 1162.

1. Erie.....	523	9. Highland.....	432
2. Hamilton.....	513	10. Athens.....	430
3. Portage.....	483	11. Ross.....	430
4. Franklin.....	473	12. Ashtabula.....	391
5. Lake.....	469	13. Licking.....	386
6. Cuyahoga.....	468	14. Lorain.....	382
7. Jackson.....	461	15. Adams.....	366
8. Fairfield.....	457	16. Lucas.....	354

B. *Counties with 201 to 350 species reported.* Estimated total number of species collected: 447 to 778.

17. Trumbull.....	348	26. Geauga.....	265
18. Hocking.....	338	27. Pickaway.....	258
19. Stark.....	322	28. Wayne.....	252
20. Scioto.....	319	29. Ottawa.....	241
21. Auglaize.....	316	30. Clark.....	229
22. Coshocton.....	314	31. Champaign.....	225
23. Summit.....	305	32. Pike.....	221
24. Meigs.....	278	33. Madison.....	214
25. Clinton.....	270	34. Clermont.....	211

C. *Counties with 101 to 200 species reported.* Estimated total number of species collected: 224 to 444.

35. Wood.....	196	50. Wyandot.....	141
36. Montgomery.....	189	51. Lawrence.....	136
37. Tuscarawas.....	186	52. Medina.....	136
38. Greene.....	185	53. Knox.....	133
39. Muskingum.....	181	54. Logan.....	125
40. Belmont.....	180	55. Butler.....	124
41. Washington.....	180	56. Perry.....	124
42. Huron.....	167	57. Warren.....	121
43. Richland.....	167	58. Williams.....	120
44. Delaware.....	163	59. Brown.....	115
45. Gallia.....	163	60. Darke.....	111
46. Vinton.....	163	61. Ashland.....	109
47. Carroll.....	155	62. Miami.....	106
48. Defiance.....	142	63. Fulton.....	103
49. Jefferson.....	142		

D. *Counties with fewer than 100 species reported.* Estimated total number of species collected: 95 to 222.

64. Holmes.....	98	77. Harrison.....	71
65. Guernsey.....	92	78. Union.....	71
66. Preble.....	91	79. Paulding.....	70
67. Shelby.....	91	80. Henry.....	67
68. Monroe.....	89	81. Allen.....	63
69. Hardin.....	86	82. Noble.....	62
70. Morgan.....	83	83. Hancock.....	59
71. Marion.....	80	84. Seneca.....	53
72. Sandusky.....	79	85. Mercer.....	48
73. Columbiana.....	77	86. Mahoning.....	46
74. Crawford.....	76	87. Putnam.....	46
75. Fayette.....	75	88. Van Wert.....	43
76. Morrow.....	74		

LITERATURE CITED

- Adams, W. 1955. Preliminary list of the Pteridophyta of Ohio. Mimeographed, distributed by Ohio Flora Committee, Ohio Academy of Science.
- Braun, E. L. 1954. Preliminary list of the monocots of Ohio (exclusive of grasses). Mimeographed, distributed by Ohio Flora Committee, Ohio Academy of Science.
- Gambill, W. G. 1955. Preliminary list of the leguminous plants of Ohio. Mimeographed, distributed by Ohio Flora Committee, Ohio Academy of Science.
- Long, R. W. 1957. A preliminary list of the Compositae of Ohio. Mimeographed, distributed by Ohio Flora Committee, Ohio Academy of Science.
- Schaffner, J. H. 1932. Revised catalog of Ohio vascular plants. Ohio Biological Survey Bulletin 25. Ohio State University, Columbus.
- Thorne, R. F. 1954. Present status of our knowledge of the vascular plant flora of Iowa. Proceedings Iowa Academy of Science. 61: 177-183.
- Weishaupt, C. G. 1954. Preliminary list of the grasses of Ohio. Mimeographed, distributed by the Ohio Flora Committee, Ohio Academy of Science.